



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Coronavirus disease 2019 (COVID-19) and psychological distress in China: Does neighbourhood matter?

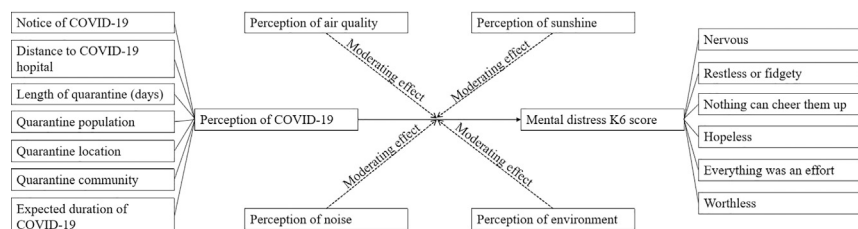
Yiyi Chen, Colin Jones ^{*}, Neil Dunse

The Urban Institute, Heriot-Watt University, Edinburgh EH14 4AS, UK

HIGHLIGHTS

- Living in a quiet neighbourhood with sufficient sunshine and good indoor air quality is associated with lesser distress.
- People living in an infected community are associated with a higher level of psychological distress.
- A person's perception of expected duration of COVID-19 increases with higher psychological level.
- Quiet and a well-maintained environment could reduce negative effects of long expected duration of COVID-19 on distress.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 24 June 2020

Received in revised form 24 November 2020

Accepted 24 November 2020

Available online 9 December 2020

Editor: Scott Sheridan

Keywords:

Coronavirus disease 2019 (COVID-19)

Psychological distress

Neighbourhood environment

Kessler psychological distress scale

ABSTRACT

Using individual data ($n = 937$) obtained from an online questionnaire between 20th January and 13th February, the early stage of the outbreak of the Coronavirus Disease 2019 (COVID-19) in 2020, we explore the direct association between people's perceptions of Coronavirus Disease 2019 (COVID-19) and psychological distress. We further examine the moderating role of neighbourhood environment and this distress. We find that people living in infected communities tend to perceive higher level of psychological distress compared to people living in uninfected communities. People's expected duration of COVID-19 is associated with higher psychological distress and this is partially moderated by the perception of neighbourhood noise level and overall environment quality. Additional results quantify the evidence that a quiet and well maintained neighbourhood environment could reduce the negative influences of expectation of a long duration of COVID-19 on people's psychological distress.

© 2020 Elsevier B.V. All rights reserved.

1. Introduction

In the early December 2019, Coronavirus Disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first found in Wuhan city and began to spread within days across all cities in urban China (Li et al., 2020; Zhu et al., 2020). It could be

transmitted from human-to-human (Chan et al., 2020; Chen et al., 2020), which led China's National Health Commission and the World Health Organization (WHO) respectively to introduce extensive household quarantine actions (see below) and an international public health emergency over the virus (BBC News, 2020). Given the lack of any specific vaccine against the virus in the short term, quarantine has been conducted as one of the most effective measures that people can follow to reduce the risk of transmission. Such an approach succeeded during the severe acute respiratory syndrome (SARS) epidemic in 2003 in which residents were observed in hospital or quarantined at home for

^{*} Corresponding author.

E-mail addresses: Yc50@hw.ac.uk (Y. Chen), C.a.jones@hw.ac.uk (C. Jones), N.A.Dunse@hw.ac.uk (N. Dunse).

10 days on average after their last exposure (Reynolds et al., 2008; Hung, 2003).

The incubation period for SARS is typically 2 to 7 days, although in some cases it may be as long as 10 days (CDC, 2020). However, unlike the short period of incubation of SARS, the incubation period of the COVID-19 is relatively long, and the incubation for COVID-19 could last up to 24 days (Zhu et al., 2020). Prolonged quarantine is a solution but might increase people's psychological distress (Hawryluck et al., 2004), especially for this long and unprecedented period. Reynolds et al. (2008) explored the relationship between people's quarantined and psychological distress by comparing health-care worker and non-health care worker during the SARS outbreak. They found that a long duration of quarantine does increase a person's psychological distress. Given the longer required quarantine period of COVID-19 and the similar transmission rate of 2–3% with SARS then psychological distress is likely to be higher (Jiang et al., 2020). This is of particular importance as recent studies have demonstrated that prolonged confinement is associated with psychological damage and strain (de Lima et al., 2020; Mazza et al., 2020).

There are other influences. Studies found that residents have a high level of psychological distress in infected communities in terms of SARS (Lau et al., 2005). Clearly there are greater fears in areas of high infection. For example, as a result in the UK during the 2020 COVID-19 epidemic many people sought to move from cities to deep rural areas to self-isolate (Brooks, 2020). People who have better knowledge of a virus transmission tend to perceive lower anxiety (Krasnik et al., 1990). Further, studies have indicated that obtaining support from family can moderate the effects of a virus outbreak on psychological distress (Myhren et al., 2011). It implies that quarantine with family members might decrease the negative effects on psychological distress.

General studies on health have noted that neighbourhood environment plays an essential role (Kawachi and Berkman, 2003). In particular, a growing body of literature have examined the association between neighbourhood environment and a person's mental disorder (Sooman and Macintyre, 1995; Wen et al., 2006). For instance, Aparicio-Ramon et al. (1993) and Rocha et al. (2012) found that neighbourhood noise could contribute to considerable stress and mental disorder. Zhang et al. (2017) explored the relationship between air quality and health symptoms though such association proved not significant. In addition, studies have suggested that residents with sufficient sunshine have a higher probability to perceive better health and wellbeing outcomes (Swanson et al., 2016). Residents living in a perceived better maintained environment are also more likely to suffer lower psychological distress compared to residents living in poor quality ones (Francis et al., 2012). Together with the direct association, Matthews and Yang (2010) found that neighbourhood environment plays a moderating role in shaping the relationship between stress and health, with adjustments for

individual characteristics. Overall these findings provide a substantial evidence base that a neighbourhood environment is significantly associated with psychological status. In addition, residential proximity to a specialist hospital can be associated with lower psychological distress (Alkozei et al., 2014).

This paper develops on this evidence base that neighbourhood environment has an influence on mental health, by focusing in particular on its moderating role on the psychological distress from COVID-19 in China. The national context was that China began a mandatory unlimited quarantine first in the city of Wuhan where the virus originated. The lockdown of the residents from 23rd January 2020 included the complete closure of the city's buses, subways, ferries, railway stations and airports. Soon after, in addition to the city of Wuhan, people in the majority of Chinese cities were required to stay in their residence, and only be allowed to venture out for necessary medical help or purchasing daily food. Checkpoints were temporarily set at the entrance of communities to enforce the compulsory restrictions on going outdoors. A health certificate and personal ID were needed to enter and leave communities (The Globe and Mail, 2020). According to the New York Times' statistical analysis of government announcements in provinces and major cities, more than half of the country's population (760 million) were affected by this restriction and confined to their residence (The New York Times, 2020). As of 30th March, most cities were still under the restriction policy though the number of new infections in China had fallen sharply compared with the peak of the outbreak during January and February (Business Today, 2020).

Within this policy and epidemic context the paper considers whether individual perceptions of COVID-19 (e.g. expected duration of COVID-19) contributes to levels of psychological distress. The various strands of the existing knowledge is combined, and related to COVID-19 in China, to develop the conceptional model or framework displayed in Fig. 1, where the definitions of these variables are given in Section 2.2. Mental state is measured by the Kessler Psychological Distress Scale (see below). In particular the following hypotheses are proposed:

Hypothesis 1. There is a higher level of psychological distress in COVID-19 infected communities compared to uninfected communities.

Hypothesis 2. The characteristics of a person's neighbourhood can influence psychological distress from COVID-19.

Hypothesis 3. Expected duration of COVID-19 is associated with a degree of psychological distress. Uncertain duration could lead to widespread job losses and prolong school closures, that in turn potentially contribute to adverse health and anxiety in accordance with previous studies (Shiller, 2020; Wang et al., 2020a). And such an effect would be moderated by a resident's neighbourhood environment.

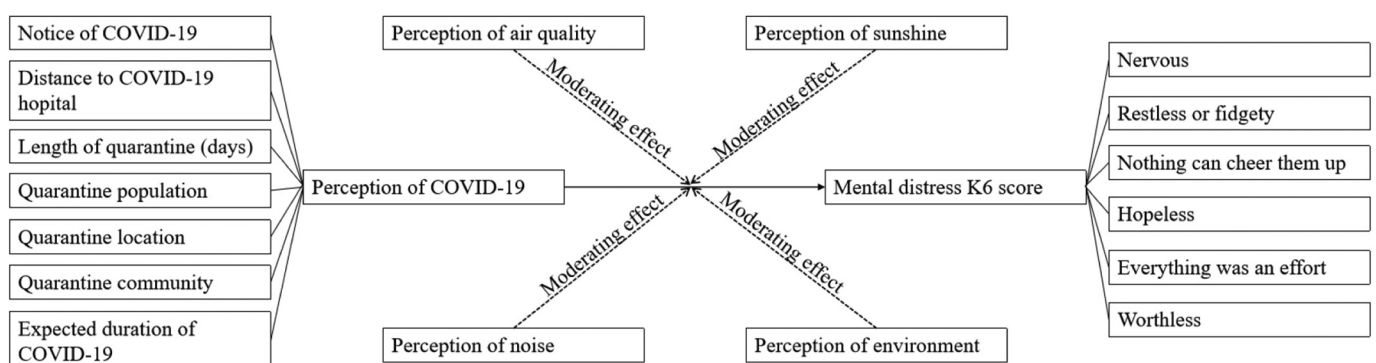


Fig. 1. Conceptual model of the moderating role of environment on association between perceptions of COVID-19 and psychological distress K6 score.

The paper now details of the data and research methods.

2. Material and methods

2.1. Study area and data description

The data was collected through an online questionnaire during the early stage of the outbreak of COVID-19 in China between 20th January and 13th February. The reason data was collected over this period is because we aimed to capture the real psychological distress caused by the lockdown effects. The effect of lockdown measures on stress might be subsequently mitigated as China's migrant workforce began returning to cities where they work after 13th February (CNN, 2020).

In all there were 1037 responses obtained by the online questionnaire crowdsourcing platform named 'Wenjuanxing', and 937 responses were used for the statistical analysis after a data cleaning process. In all 100 of the respondents were excluded because they filled in invalid information in the options that related to the quarantine location. The survey collected a range of perceptions of COVID-19, an individual's socio-economic-demographic characteristics, lifestyle status, psychological distress and perceptions of a respondent's neighbourhood environment. It was a nationwide survey encompassing 230 cities in urban China. In the analysis individuals' data is nested into a city. Ethics approval was obtained from the School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University.

2.2. Variables definition

In this section details of the variables derived from the survey are presented.

2.2.1. Kessler psychological distress scale, K6

Psychological distress is the dependent variable in this study. Psychological distress was assessed with the Kessler psychological distress scale K6 score (Kessler et al., 2002). K6 has been widely used and shown acceptable reliability and validity in previous mental health surveys (Fushimi et al., 2012; Hill et al., 2009). The scale includes six items associated with psychological distress in the past 4 weeks. It is based on 6 questions (used in our survey): how often have you been feeling (a) nervous, (b) restless or fidgety, (c) so sad nothing could cheer them up, (d) hopeless, (e) everything was an effort, and (f) worthless? An answer to each question is via a 5-point Likert scale ranging from 0 'never' to 4 'very often'. A value of 13 or higher on the K6 indicates high psychological distress. Values between 8 and 12 indicate moderate psychological distress and a value between 0 and 7 denotes to low psychological distress (Kessler et al., 2002).

2.2.2. Perceptions of COVID-19

Different aspects of people's perception and experience of COVID-19 are considered. Understanding is measured by the following question: 'How much do you know about the COVID-19?'. Response categories are in a Likert scale ranging from (1) know nothing about the COVID-19 to (5) know everything about the COVID-19. A person's quarantine status is measured by asking how long you have been isolated: (1) has not started yet; (2) within a week; (3) more than a week but less than 14 days; (4) over 14 days. The occurrence of a jointly quarantined population (Quarantine Population in Fig. 1) is measured by asking the question: 'how many people are currently isolated with you?'. Response categories ranged from (1) none to (5) quarantined with at least four people. A person's perception of distance from residence to COVID-19 hospital is measured by asking how far it is from your house to the nearest hospital which is specifically used for curing COVID-19 patients: (1) very far, at least an hour's drive; (2) Far, at least half hour's drive; (3) Close, at least 10 to 30 min' drive; (4) very close, 5 min drive. A quarantined residential community is measured with the following question: 'Whether lockdown measures were performed in your community

for preventing the spread of COVID-19?'. This item is coded (1) yes or (0) no. An infected residential community is measured with the following question: 'Whether there are confirmed cases in your residential community or not?'. The item is coded (1) yes or (0) no. Quarantine location is measured by asking, 'Where are you quarantined now?': (1) own house or flat; (2) hotel; or (3) hospital. Lastly, we asked people's expected duration of COVID-19 with four options: (1) the outbreak will last for no more than 1 month; (2) the outbreak will last between 1 and 2 months; (3) the outbreak will last between 2 and 3 months; (4) the outbreak will last for more than 3 months.

2.2.3. Neighbourhood environment

Neighbourhood environment is defined by a limited number of characteristics applicable to the Chinese context as discussed above – noise, sunshine, air quality, and overall quality measured on five point Likert scales. Perception of noise is assessed with the following question: 'How would you rate your neighbourhood noise level overall?' Response categories ranged from (1) extremely quiet to (5) extremely noisy. Perception of sunshine is measured by the following question: 'How would you rate your indoor sunshine level overall?' Response categories ranged from (1) extremely little indoor sunshine to (5) extremely sufficient indoor sunshine. Perception of indoor air quality is measured with the following question: 'How would you rate your indoor air quality level overall?' Response categories ranged from (1) extremely bad indoor to (5) extremely good. Perception of overall environment quality is measured through the following question: 'How would you rate your neighbourhood environment quality overall?' Response categories ranged from (1) extremely very poor to (5) extremely very good. Additionally, we measure neighbourhood social cohesion by asking the question, 'How satisfied are you with your relationship with your neighbours?' Response categories ranged from (1) extremely unsatisfied (5) to extremely satisfied.

2.2.4. Lifestyle

Several indicators of lifestyle have been identified as significant factors influencing psychological distress. These indicators include physical health status, regular physical exercise, smoking, drinking, and sleeping hours (Weyerer and Kupfer, 1994; Turner and Kelly, 2000; Marchand et al., 2003; Lawrence et al., 2011; Breslau et al., 1996; Meerlo et al., 2008). People's physical health status is measured with the question: 'Have you been diagnosed with a chronic disease in the past six months?' This item is coded (1) yes or (0) no. People's regular physical exercise is assessed with the question: 'How often do you exercise during the outbreak of COVID-19?' Response categories ranged from (1) never to (5) very often. Sleeping hours are categorized into four categories coded as: (1) within 7 h per day; (2) between 7 and 9 h; (3) between 9 and 11 h; (4) more than 11 h per day. Furthermore, we measure smoking and drinking with two items. Smoking is measured with the following question: 'Have you smoked in the last month?'. This item is coded (1) for smoker or (0) otherwise. Similarly, we measure drinking by the following question: 'Have you drunk more than 3 times per week in the last month?'. This item is coded (1) for drinkers or (0) otherwise.

2.2.5. Socio-economic-demographic characteristics

As shown by previous studies (Lincoln et al., 2010; Talala et al., 2008; Cunningham and Paradies, 2012), the proneness to psychological stress differs according to a person's characteristics. We statistically control for a range of these characteristics namely:

- Gender (1 = male, 0 = female);
- Age (measured in continuous years);
- Marital status (1 = married, 0 = otherwise);
- Educational attainment level (1 = illiteracy, 2 = primary, 3 = junior high school, 4 = technical secondary school, 5 = high school, 6 = college, 7 = undergraduate, 8 = master, 9 = PhD and above);
- Household income level (1 = monthly earnings of ≤3000 yuan, 2 =

monthly earnings of 3000–10,000 yuan, 3 = monthly earnings of 10,000–20,000 yuan, 4 = monthly earnings of 20,000–30,000 yuan, 5 = monthly earnings of 30,000–50,000 yuan, 6 = monthly earnings of >50,000).

- Residence location (1 = urban residents, 0 = rural residents)

2.3. Statistical analysis

We apply multi-level linear regression analyses to explore the effect of perceptions of COVID-19 on psychological distress and the moderating role of perceptions of neighbourhood. In particular, we regress people's socio-economic-demographic and lifestyle characteristics on psychological distress (Table 2, Model 1), then controlling for perceptions of the neighbourhood environment (Model 2), and perceptions of COVID-19 (Model 3) respectively. The overarching statistical is shown as follows:

$$K6_{ij} = \beta_0 + \beta_1 \text{Environment}_j + \beta_2 \text{COVID-19}_j + \beta_3 \text{Personal characteristics}_{ij} + \eta_j \quad (1)$$

Eq. (1) relates the models 1 to 3 in Table 2 that looks at the component factor on K6. In terms of Eq. (1) subscripts *i* represents individuals and *j* represents cities. $K6_{ijk} = \beta_0 + \beta_1 \text{DurationNCP}_k + \beta_2 \text{Environment}_{jk} + \beta_3 \text{Environment}_{jk} \cdot \text{DurationNCP}_k + \beta_4 \text{Covariates}_{jk} + \beta_5 \text{Covariates}_{jk} \cdot \text{Environment}_{jk} + \eta_{ijk} + \mu_k$ therefore refers to the intercept of K6 at city level *j*. β_1 to β_5 denotes to the corresponding coefficients. Environment_j represents a vector of the city-level variables of perceptions of the neighbourhood environment. COVID-19_j represents a vector of city level variables of perceptions of COVID-19. $\text{Personal characteristics}_{ij}$ represents a vector of individual-level personal characteristics. η_j refers to a city level residual that represents the difference between an individuals' mean and city level *j*'s mean.

To test whether the effect of perceptions of COVID-19 on psychological distress is influenced by the perceptions of neighbourhood environment characteristics we introduce and estimate four cross-level interaction items into Model 6 in Table 3 while following the multi-level analysis study (Davidian, 2003). We mainly focus on the interactive term of expected duration of COVID-19 and perceptions of neighbourhood environment, for as noted earlier uncertain duration can contribute to adverse health and anxiety. Four interaction terms are shown as:

- Expected duration of COVID-19 * perception of neighbourhood noise;
- Expected duration of COVID-19 * perception of indoor air quality;
- Expected duration of COVID-19 * perception of sunshine;
- Expected duration of COVID-19 * perception of overall environment quality;

$$K6_{ij} = \beta_0 + \beta_1 \text{DurationCOVID-19}_j + \beta_2 \text{Environment}_j + \beta_3 \text{Environment}_j \cdot \text{DurationCOVID-19}_j + \beta_4 \text{Personal characteristics}_{ij} + \eta_j \quad (2)$$

Eq. (2) with expected duration of COVID-19 as its key independent variable is the basis of the three models in Table 3. In Model 6, $\text{Environment}_j \cdot \text{Expected duration of COVID-19}_j$ represents a vector of cross-level interactive of expected duration of COVID-19 and perceptions of neighbourhood environment characteristics. β_3 represents the coefficient of the interaction effect.

All continuous variables are centred in the interaction part to avoid problems due to multicollinearity (Aiken et al., 1991). To test the potential collinearity between perception of COVID-19, socio-economic-demographic characteristics, lifestyle indicators, perceptions of neighbourhood environment and psychological distress in the estimated model, we apply the variation inflation factor (VIF) diagnostics in STATA. The results show that none of the VIFs are greater

than 2 which indicates that there are no serious collinearity issues in the estimation model.

The variables are first analysed in SPSS to test their reliability. Cronbach's (1951) alpha is the coefficient conducted to estimate the reliability of instruments based on internal consistency. Cronbach's alpha reliability coefficient normally has values from 0 to 1 where higher values refer to a greater internal consistency of variables in the scale. Results show acceptable validity of the K6 with a reliability coefficient (alpha) of 0.73 > 0.70. Note the reliability coefficient (alpha) of 0.70 or higher is considered an acceptable reliability in previous studies in SPSS (Nunnally, 1994; George and Mallery, 2003; Bolarinwa, 2015). The multi-level linear regression analysis is performed using STATA, version 14 for Windows.

3. Results

The paper now proceeds by first setting out some basic descriptive analysis. It then assesses Hypothesis 1 on impact of a virus affected area on psychological distress. From there it explores the relationship between person's neighbourhood and psychological distress to address our Hypothesis 2. Lastly, we analyze the moderating role of residents' perceptions of neighbourhood environment in the relationship between the expected duration of COVID-19 and the degree of psychological distress, namely Hypothesis 3.

3.1. Descriptive analysis

Table 1 presents the descriptive characteristics for the sample (*n* = 937). The respondents are predominantly young with 59% aged between 18 and 34 years and around one third (34.7%) are male. Just over three fifths (60.8%) are married and almost a quarter (24.5%) have attained a degree and above. In total, 35.5% residents monthly earn over 10,000 yuan which is higher than the national average of 4340 yuan according to the 2019 wave of the China Household Finance Survey (CHFS).¹ Turning to the people lifestyle indicators, 21.3% people state they sleep less than 7 h per day and 24.6% report they sleep over 9 h per day. The respondents generally have a sedentary lifestyle with nearly 50% people reporting that they exercise less than once a week. More than one fifth, 21.7%, of respondents report they have smoked in the last four weeks, which is lower than the national average of 26.8% reported by the fourth wave of the CFPS² conducted in 2018. Further, 20.1% people state they have drunk more than 3 times per week in the last month, which is higher than the national average of 14.0% reported by the fourth wave of the CFPS conducted in 2018. Overall, the sample is primarily of young relatively well educated adults which perhaps explains the average score of K6 as 9.2 which suggests respondents perceive only moderate psychological distress. In comparison the average K6 score reported in CFPS 2018 rated was 9.4, which is higher than the score of K6 in our study.

Key statistics on respondents' quarantine experience, perceptions about COVID-19, and their neighbourhood environment can be reported as follows:

- 82.6% live in residential communities that have been subject to the lockdown measure, as the response to China's CDC.
- 23.4% live in residential communities that have confirmed COVID-19 cases while 76.6% live in a residential community with no confirmed cases.
- 52.2% individuals have a great understanding of COVID-19, followed by 33.1% who rate knowledge of COVID-19 as neutral.
- About 73% of individuals have experienced quarantine for over a week.

¹ CHFS has conducted several follow-up surveys since 2011

² The China Family Panel Studies (CFPS), launched by Peking University, is longitudinal social survey consisting four wave thus far. Four waves of the CFPS are including CFPS 2012, CFPS 2014, CFPS 2016 and CFPS 2018. CFPS 2010 is conducted as the baseline survey.

Table 1
Summary statistics of variables included in regression analyses.

Variables	n	Proportion (%)
Dependent variables		
K6 Score (0–30)	937	9.2
Independent variables		
Understanding of COVID-19		
Know nothing about the COVID-19	53	5.7
Know little about the COVID-19	85	9.1
Neutral	310	33.1
Know something about the COVID-19	385	41.1
Know everything about the COVID-19	104	11.1
Length of quarantine (days)		
have not started yet	91	9.7
Within a week	171	18.3
More than a week but less than 14 days	187	19.9
More than 14 days	488	52.1
Quarantine population		
Solo quarantine	150	16.0
Quarantine with one person	249	26.6
Quarantine with two people	237	25.3
Quarantine with three people	160	17.1
Quarantine with at least four people	141	15.0
Distance to COVID-19 hospital		
Very far, at least an hour's drive	205	21.9
Far, at least half hour's drive	348	37.1
Close, at least 10 min to 30 min drive	306	32.7
Very close, 5 min drive	78	8.3
Quarantine residential community		
Communities have been conducted the closed-off management	774	82.6
Communities have not been conducted the closed-off management	163	17.4
Infected residential community		
There are confirmed cases in the residential community	219	23.4
No confirmed cases in the residential community	718	76.6
Quarantine location		
Own house or flat	732	87.1
Hotel	141	15.1
Hospital	64	6.8
Expected duration of COVID-19		
The outbreak will last no more than 1 month	352	37.5
The outbreak will last between 1 and 2 months	392	41.8
The outbreak will last between 2 and 3 months	156	16.7
The outbreak will last more than 3 months	37	4.0
Personal characteristics		
Sex		
Male	325	34.7
Female	612	65.3
Age		
18–24	172	18.3
25–34	381	40.7
35–44	238	25.4
45–54	101	10.8
55–64	36	3.8
65–74	7	0.8
75+	2	0.2
Marital status		
Married	570	60.8
Unmarried	367	39.2
Education		
Illiteracy	29	3.1
Primary	72	7.7
Junior high school	181	19.3
Technical secondary school	137	14.6
High school	132	14.1
College	156	16.7
Undergraduate	169	18.0
Master	49	5.2
PhD and above	12	1.3
Household income level		
Monthly earnings of ≤3000 yuan	245	26.2
Monthly earnings of 3000–10,000 yuan	368	39.3
Monthly earnings of 10,000–20,000 yuan	183	19.5
Monthly earnings of 20,000–30,000 yuan	69	7.4
Monthly earnings of 30,000–50,000 yuan	29	3.1
Monthly earnings of ≥50,000 yuan	43	4.6
Residence location		

Table 1 (continued)

Variables	n	Proportion (%)
Urban residents	489	52.2
Rural residents	448	47.8
Neighbourly relationship		
Extremely unsatisfied with the neighbourly relationship	44	4.7
Unsatisfied with the neighbourly relationship	89	9.5
Neutral	353	37.7
Satisfied with the neighbourly relationship	334	35.7
Extremely satisfied with the neighbourly relationship	117	12.4
Sleep hours		
Within 7 h	200	21.3
Between 7 and 9 h	506	54.1
Between 9 and 11 h	185	19.7
More than 11 h	46	4.9
Smoke		
Smoker	203	21.7
Non-smoker	734	78.3
Drink		
Drinker	188	20.1
Non-drinker	749	79.9
Physical exercise		
Never	211	22.5
Physical exercise only 1 per week	255	27.2
Physical exercise 2–4 times per week	295	31.5
Physical exercise 5–7 times per week	119	12.7
Physical exercise more than 7 times per week	57	6.1
Physical health status		
Have a chronic disease	178	19
No chronic disease	759	81
Neighbourhood characteristics		
Perception of neighbourhood noise		
Extremely quite	279	29.8
Quite	373	39.8
Neutral	206	21.9
Noisy	67	7.2
Extremely noisy	12	1.3
Perception of sunshine		
Extremely little indoor sunshine	42	4.5
Little indoor sunshine	123	13.1
Neutral	284	30.3
Sufficient indoor sunshine	358	38.2
Extremely sufficient indoor sunshine	130	13.9
Perception of air quality		
Extremely bad indoor air quality	41	4.4
Bad indoor air quality	104	11.1
Neutral	309	33.0
Good indoor air quality	367	39.2
Extremely good indoor air quality	116	12.4
Perception of overall environment quality		
Environment maintain in very poor quality	52	5.6
Environment maintain in poor quality	123	13.1
Neutral	405	43.2
Environment maintain in good quality	263	28.1
Environment maintain in very good quality	94	10.0

Notes: We used the mean to present the K6 score.

- 16% of people are isolated alone and over 32% people are isolated with more than 2 people.
- 40% of people report that they live within close distance of a COVID-19 hospital.
- 87.1% of people are isolated in their house or flat while 6.8% are isolated in the hospital.
- About 80% of people are optimistic about the COVID-19, and suggesting that the duration of COVID-19 will last for no more than 2 months.
- In terms of people' perception of environment, 8.5% report that their residential environment is noisy.
- Over 50% of people report they have either sufficient or extremely sufficient indoor sunshine.
- 51.6% of people report they have good indoor air quality compared to 15.6 which rate bad and extremely bad indoor air quality.
- 38.1% of people report their residential environment is good quality.
- Less than 14.2% of people report they are unsatisfied and extremely unsatisfied with their neighbour relationships

3.2. Baseline results

Table 2 shows the results of the multi-level linear regression on psychological distress. Model 1 represents the baseline results controlling for socio-economic-demographic characteristics and lifestyle characteristics. The results suggest that people with higher educational attainment

Table 2

Multi-level linear regression coefficients for the effects of COVID-19, socio-economic-demographic characteristics, lifestyle and neighbourhood perceptions on respondents' K6.

	Model 1	Model 2	Model 3
Sex	0.585 (0.475)	0.509 (0.469)	0.267 (0.462)
Age	0.306 (0.211)	0.330 (0.207)	0.146 (0.205)
Marital status	-0.516 (0.459)	-0.197 (0.454)	0.035 (0.449)
Education	-0.497*** (0.125)	-0.379*** (0.124)	-0.386*** (0.123)
Household income level	0.249 (0.179)	0.224 (0.177)	0.150 (0.176)
Residence location	-0.172 (0.441)	-0.132 (0.434)	-0.301 (0.440)
Perception of neighbourly relationship	-1.174*** (0.227)	-0.600** (0.247)	-0.509** (0.242)
Sleep hours≤7 h	Reference	Reference	Reference
7<sleep hours≤9	-0.331 (0.535)	-0.275 (0.526)	-0.370 (0.516)
9<sleep hours≤11	1.292* (0.664)	1.148* (0.652)	0.783 (0.640)
Sleep hours>11	-0.127 (1.038)	0.058 (1.026)	-0.681 (1.007)
Smoke	1.038* (0.594)	0.794 (0.585)	0.638 (0.575)
Drink	1.192** (0.607)	0.792 (0.602)	0.622 (0.591)
Physical exercise	-0.032 (0.187)	-0.040 (0.185)	-0.073 (0.183)
Physical health status	3.341*** (0.593)	3.029*** (0.587)	2.471*** (0.586)
Perception of noise		0.491** (0.221)	0.427* (0.220)
Perception of sunshine		-0.771*** (0.270)	-0.567** (0.267)
Perception of indoor air quality		-0.672** (0.284)	-0.508* (0.281)
Perception of overall environment quality		-0.054 (0.249)	0.013 (0.245)
Understanding of COVID-19			0.199 (0.222)
Length of quarantine (days)			-0.149 (0.221)
Quarantine residential community			-0.440 (0.559)
Infected residential community			1.175*** (0.549)
Quarantine location			-0.338 (0.847)
Distance to COVID-19 hospital			-0.423* (0.234)
Quarantine population			-0.364** (0.172)
Expected duration of COVID-19			1.275*** (0.252)
Constants	13.171*** (1.211)	14.829*** (1.447)	14.002*** (1.828)
Var (city-level constant)	0.511*** (0.192)	0.392* (0.222)	0.322 (0.241)
Var (residual)	1.814*** (0.025)	1.799*** (0.025)	1.776*** (0.025)
N	937	937	937
AIC	6144.641	6116.889	6085.208
BIC	6226.967	6218.585	6225.646
chi2	201.309	248.759	312.377
P	0.000	0.000	0.000

Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. AIC: Akaike information criterion; BIC: Bayesian information criterion.

level are more likely to perceive lower psychological distress (coefficient -0.50, standard error 0.13, $p < 0.01$). On the other hand a person's psychological distress decreases with the neighbourly relationship (coefficient -1.17, standard error 0.23, $p < 0.01$). However, we found no significant association between sex, age, marital status, household income level, residence location and a person's psychological distress. Additionally, we find that people who sleep between 9 and 11 h per day tend to perceive higher psychological distress compared to those sleep less than 7 h per day (coefficient 1.29, standard error 0.66, $p < 0.10$). A smoker tends to perceive higher psychological distress compared with a non-smoker (coefficient 1.04, standard error 0.59, $p < 0.10$). A drinker is more likely to perceive higher psychological distress (coefficient 1.19, standard error 0.61, $p < 0.05$). People with physical diseases are more likely to perceive higher psychological distress than those without (coefficient 3.34, standard error 0.59, $p < 0.01$).

Indicators of perceptions of the environment are added in Model 2 of Table 2 with an adjustment for demographic characteristics and lifestyle indicators. Results suggest that a person's psychological distress increases with the perception of neighbourhood noise level (coefficient 0.49, standard error 0.22, $p < 0.05$) and decreases with both perception of sunshine (coefficient -0.77, standard error 0.27, $p < 0.01$), as well as the indoor air quality (coefficient -0.67, standard error 0.28, $p < 0.05$).

Lastly, the main results from Model 3 (Table 2) suggest that people living in the infected residential communities are more likely to perceive higher psychological distress compared to people living in uninfected communities (coefficient 1.18, standard error 0.55, $p < 0.01$), which is consistent with Hypothesis 1. Moreover, we find that people living adjacent to a COVID-19 hospital are more likely to have lower psychological distress compared to people living far from one (coefficient -0.42, standard error 0.23, $p < 0.10$). Isolation with other family members decreases a person's psychological distress (coefficient -0.36, standard error 0.17, $p < 0.05$). The longer a person expects the duration of COVID-19 the higher psychological distress they may perceive (coefficient 1.28, standard error 0.25, $p < 0.01$).

3.3. Moderation analysis

The results from the multi-level linear regression indicate that expected duration of COVID-19 is robust and significant after adjustment for perceptions of neighbourhood environment characteristics and personal characteristics. We focus on this key indicator that represents the overall perception of COVID-19 to examine the moderation effects of perceptions of neighbourhood environment on psychological distress. Table 3 shows the multivariate results for psychological distress. In line with the baseline results from Model 1 it suggests that expected duration of COVID-19 increases with psychological distress (coefficient 1.39, standard error = 0.26, $p < 0.01$). Such effect is reduced by 10.4% but remains statistically significant after adjusting for perceptions of the environment. Lastly, we add cross-level interaction effects in Model 6. Results indicate that the effect of expected duration of COVID-19 on people's psychological distress vary by people's perception of neighbourhood noise and overall environment quality ($p < 0.05$).

In addition, we explore whether effects of expected duration of COVID-19 on people's psychological distress are related to reverse causation. We examine the interaction effects of whether people living in either a quarantined community or an infected community on people's psychological distress vary by people's perceptions of neighbourhood characteristics. Specifically, we find that people's perception of sunshine significantly moderated the relationship between quarantine community and psychological distress ($p < 0.05$). An additional result shows that there is no significant moderating role for perceptions of neighbourhood environmental characteristics on the association between living in an infected community and psychological distress. Note therefore we have omitted the results in Table 3.

Table 3

Multi-level linear regression coefficients for the moderating effects of neighbourhood perceptions and the expected duration of COVID-19 on residents' K6 status.

	Model 4	Model 5	Model 6
Expected duration of COVID-19	1.391*** (0.258)	1.287*** (0.254)	1.333*** (0.255)
Sex	0.545 (0.469)	0.470 (0.463)	0.508 (0.462)
Age	0.193 (0.209)	0.233 (0.206)	0.200 (0.205)
Marital status	−0.410 (0.454)	−0.120 (0.449)	−0.092 (0.449)
Education	−0.549*** (0.123)	−0.431*** (0.123)	−0.440*** (0.123)
Household income level	0.158 (0.178)	0.143 (0.176)	0.100 (0.176)
Residence location	−0.292 (0.436)	−0.237 (0.430)	−0.241 (0.428)
Sleep hours	0.232 (0.272)	0.229 (0.269)	0.203 (0.268)
Smoke	0.982* (0.587)	0.744 (0.579)	0.699 (0.578)
Drink	1.112* (0.600)	0.734 (0.594)	0.763 (0.592)
Physical exercise	−0.043 (0.185)	−0.048 (0.183)	−0.031 (0.182)
Physical health status	3.075*** (0.587)	2.778*** (0.581)	2.767*** (0.581)
Perception of neighbourly relationship	−1.114*** (0.225)	−0.557** (0.244)	−0.550** (0.243)
Perception of neighbourhood noise		0.406* (0.219)	1.320*** (0.507)
Perception of sunshine		−0.656** (0.281)	−0.680 (0.695)
Perception of indoor air quality		−0.774*** (0.266)	−0.038 (0.632)
Perception of overall environment quality		−0.063 (0.246)	−0.979* (0.575)
Expected duration of COVID-19 × Perception of neighbourhood noise			−0.474** (0.237)
Expected duration of COVID-19 × Perception of sunshine			−0.377 (0.290)
Expected duration of COVID-19 × Perception of indoor air quality			0.009 (0.324)
Expected duration of COVID-19 × Perception of overall environment quality			0.487* (0.272)
Constants	10.823*** (1.300)	12.845*** (1.514)	9.723*** (1.145)
Var (city-level constant)	0.499*** (0.190)	0.369* (0.221)	0.381* (0.218)
Var (residual)	1.802*** (0.025)	1.789*** (0.025)	1.784*** (0.025)
N	937.000	937.000	937.000
Aic	6120.826	6094.731	6095.116
Bic	6198.309	6191.585	6211.340
chi2	228.139	274.996	284.300
P	0.000	0.000	0.000

Notes: All continue variables have been centered. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. AIC: Akaike information criterion; BIC: Bayesian information criterion.

Fig. 2a and b graphically illustrate the relative impact on psychological distress of the expected duration of COVID-19 and perceptions of neighbourhood noise and overall environment quality as estimated in Model 6. Distress increases on average from just over 7.6 on the K6 scale to more than 11.5 dependent on how long people expect the pandemic to last, an increase of approximately 56%. Fig. 2a shows that people subject to an extremely high neighbourhood noise level perceive higher psychological distress. Fig. 2b also shows that people that expect a longer duration of COVID-19 with a better environment quality are more likely to feel a lower psychological distress than people living in worse environment quality.

4. Discussion

In this paper, we used nationwide data collected from an online survey to explore the association between perceptions of COVID-19 and psychological distress during the early stage of the outbreak of the COVID-19 virus in China. We further examined whether the association between the expected duration of COVID-19 and psychological distress is moderated by the neighbourhood environment.

4.1. Discussion of key findings

We find that people living in an infected residential community are associated with a much higher level of psychological distress, which is consistent with our Hypothesis 1 and in line with findings in terms of SARS (Lau et al., 2005). This is reasonable since considerable fear of contagion from proximity potentially contributes to psychological distress, especially when the virus outbreak has not been completely controlled in the early stage (Chen et al., 2005). Given that at the time of the study the course of the pandemic was unclear the most significant variable affecting a person's distress was their expected duration of the COVID-19.

The study also finds that stress is reduced by supporting mechanisms. Residential proximity to a COVID-19 hospital is associated with lower psychological stress. Furthermore, we find that people tend to perceive lower psychological distress if they live with more than one family member. One underlying mechanism might be people may perceive better family support if they are isolated with more family members. This is consistent with previous general research that family support plays an essential role in influencing a person's psychological distress (Northouse et al., 1998; Baider et al., 2003). Additionally, we find that a person's expected duration of COVID-19 significantly increases psychological distress by the order of 56%. This finding is consistent with Reynolds et al. (2008) who find that the long duration of quarantine leads to higher psychological distress.

Regarding demographic characteristics, we find no significant association between sex, age, marital status, household income level, residence location and a person's psychological distress. These findings are inconsistent with current studies related to COVID-19, suggesting that female gender is significantly associated with higher level of stress and depression (Mazza et al., 2020; Wang et al., 2020b). Another longitudinal study mentions that younger age respondents are more likely to perceive higher psychological distress as they are affected by prolonged school closures (Wang et al., 2020a). One possible explanation might be an official statement of school closures was not announced at a very early stage of the outbreak. It therefore did not have a substantial negative effect on younger age respondents' stress level.

Our study specifically focuses on the influence of the neighbourhood environment. The role of neighbourhood can have an amplifying or moderating role on psychological distress. Living in a neighbourhood with quiet, sufficient sunshine and good indoor air quality is found to be associated with lesser psychological distress, which is consistent with our Hypothesis 2. It is noteworthy that these results remain statistically significant after adjustment for perceptions of COVID-19. Further, we find that the association between perceptions of sunshine and indoor air quality and psychological distress weaken dramatically after adjustment for interaction terms.

By contrast, the relationship between perceptions of neighbourhood noise and overall environment quality and psychological distress are highly statistically significant when we adjust for interaction terms. Additionally, our results also suggest that the relationship between expected duration of COVID-19 and psychological distress is significantly moderated by higher neighbourhood noise level. In absolute terms, such an effect is not too substantial but needs to be seen in terms of our sample primarily covering a narrow young age group compared to the national age spectrum. And this could be interpreted as higher density increasing stress.

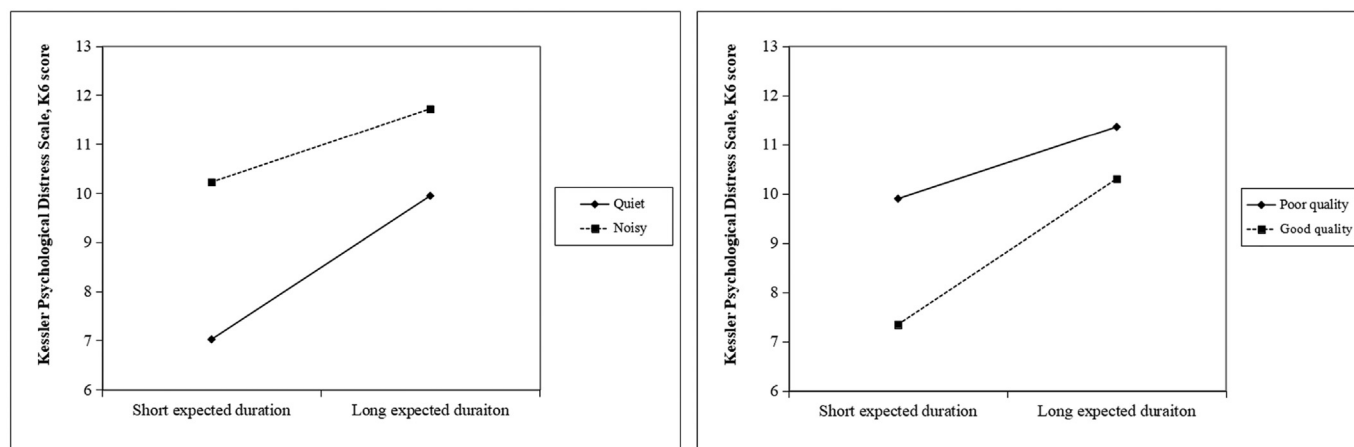


Fig. 2. a and b The impact of the perceptions of noise and overall environment quality respectively on the expected duration of COVID-19 on psychological distress.

We also find that residents who have a longer expected duration of COVID-19 and living in a better environment have statistically significant influences on decreasing psychological distress compared to residents living in a worse environment quality, which is in line with our Hypothesis 3. These findings would lead to the conclusion that a quiet and well maintained neighbourhood environment could reduce the negative effects of the expectation of a long duration of COVID-19 on people's psychological distress.

4.2. Contribution and limitations

This study has several limitations. First, we cannot avoid the casual effect that may lead to potential bias to the estimations since our study applied a cross-sectional design. Nevertheless, our sample was collected in a relatively short time in the early stage of the outbreak of the COVID-19 in China, which might mitigate such bias to some extent. Second, since perception variables are self-reported and variables were measured as the focal perception of the survey participants that may also create potential bias. Third, an online survey is not necessarily representative, especially as it has high proportion mainly of the young generation. Lastly, we have not collected data on all factors that may potentially contribute to residents' mental health benefits, both in terms of personal characteristics and neighbourhood attributes. In the Chinese context wearing a mask could have influenced anxiety during this period. Studies have indicated that wearing a mask can reduce the fear of a virus (Lau et al., 2003). The reason we exclude this essential indicator is that people found it hard to purchase the mask during the outbreak of COVID-19 with most of them allocated to Wuhan city for emergency use.

Notwithstanding these limitations we make several contributions to the existing literature in this study. First, we contribute to previous research by evaluating the direct effect of people's perceptions of COVID-19 on psychological distress during the peak of the virus outbreak. Second, we find that a person's neighbourhood environment can be a potential mechanism in influencing people's psychological distress though insignificant correlates has been found in terms of the perceptions of overall environment quality. It sheds lights in revealing the impact of people's subjective perceptions of the environment on residents' psychological distress. It is feasible to expect that a well-maintained neighbourhood environment can buffer against the adverse psychological distress.

In addition, this study also highlights the importance of perceptions of neighbourhood environment (e.g. noise and overall environment quality) that substantially contribute to moderate the negative perceptions of COVID-19 on a person's psychological distress. Stakeholders should pay more attention to maintaining neighbourhoods with high quality and aesthetic natural elements that may potentially improve people's mental health outcome.

Future research should focus more on the influences on psychological distress in other countries with lower density and different restriction policies, and thereby explore the further role of neighbourhood. Regional influences brought about by cities with different infection levels of COVID-19 might need to be considered if data is available. Interventions, such as promoting public compliance with government health recommendations to control the spread of a virus should also be included. Such research could focus on the public perceptions and efficacy of a range of interventions (Roma et al., 2020). Meanwhile, physical characteristics such as green space should be taken into account in a future study since previous studies have indicated that the percentage of green space. It could contribute to improve people's wellbeing and offer better opportunities for exercise if this is permitted during a lockdown period (Van den Berg et al., 2010).

CRediT authorship contribution statement

All the authors contributed to the research. The primary research was undertaken by Yiyi Chen under the guidance of Colin Jones and Neil Dunse. All three authors have been involved in the drafting and writing of the paper.

Declaration of competing interest

None.

Acknowledgement

Views expressed in this paper are those of the authors.

References

- Aiken, L.S., West, S.G., Reno, R.R., 1991. *Multiple Regression: Testing and Interpreting Interactions*. Sage, New York.
- Alkozei, A., McMahon, E., Lahav, A., 2014. Stress levels and depressive symptoms in NICU mothers in the early postpartum period. *The Journal of Maternal-Fetal Neonatal Medicine* 27, 1738–1743. <https://doi.org/10.3109/14767058.2014.942626>.
- Aparicio-Ramon, D.V., Morales, M.S.-V., Garcia, A.G., Llopis, A.G., Ruano, L., Sanchez, A.M., Ferrer, E.C., 1993. *Subjective annoyance caused by environmental noise*. *J. Environ. Pathol. Toxicol. Oncol.* 12, 237–243.
- Baider, L., Ever-Hadani, P., Goldzweig, G., Wygoda, M.R., Peretz, T., 2003. Is perceived family support a relevant variable in psychological distress?: a sample of prostate and breast cancer couples. *J. Psychosom. Res.* 55, 453–460. [https://doi.org/10.1016/S0022-3999\(03\)00502-6](https://doi.org/10.1016/S0022-3999(03)00502-6).
- BBC news, 2020. New China virus: warning against cover-up as number of cases jumps. <https://www.bbc.co.uk/news/world-asia-china-51185836>. Accessed March 22, 2020.
- Bolarinwa, O.A., 2015. Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. *Nigerian Postgraduate Medical Journal* 22, 195. <https://doi.org/10.4103/1117-1936.173959>.
- Breslau, N., Roth, T., Rosenthal, L., Andreski, P., 1996. Sleep disturbance and psychiatric disorders: a longitudinal epidemiological study of young adults. *Biol. Psychiatry* 39, 411–418. [https://doi.org/10.1016/0006-3223\(95\)00188-3](https://doi.org/10.1016/0006-3223(95)00188-3).

- Brooks, L., 2020. Scottish government 'furious' at travellers to highlands and islands, *Guardian* 22 March. <https://www.theguardian.com/world/2020/mar/21/scottish-government-furious-at-travellers-to-highlands-and-islands>. Accessed March 22, 2020.
- Business Today, 2020. Coronavirus: China reports drop in new cases, zero in Hubei for sixth day. <https://www.businesstoday.in/current/world/coronavirus-china-reports-drop-in-new-cases-zero-in-hubei-for-sixth-day/story/399569.html>. Accessed March 22, 2020.
- CDC, 2020. Frequently asked questions about SARS. <https://www.cdc.gov/sars/about/faq.html>. Accessed March 22, 2020.
- Chan, J.F.-W., Yuan, S., Kok, K.-H., To, K.K.-W., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C.C.-Y., Poon, R.W.-S., 2020. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet* 395, 514–523. [https://doi.org/10.1016/S0140-6736\(20\)30154-9](https://doi.org/10.1016/S0140-6736(20)30154-9).
- Chen, C.-S., Wu, H.-Y., Yang, P., Yen, C.-F., 2005. Psychological distress of nurses in Taiwan who worked during the outbreak of SARS. *Psychiatr. Serv.* 56, 76–79. <https://doi.org/10.1176/appi.ps.56.1.76>.
- Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., 2020. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* [https://doi.org/10.1016/S0140-6736\(20\)30211-7](https://doi.org/10.1016/S0140-6736(20)30211-7).
- CNN, 2020. Working from home, temperature checks and quarantines: how China's companies are trying to get back to business. <https://edition.cnn.com/2020/02/10/business/china-companies-return-to-work-coronavirus/index.html>. Accessed October 30, 2020.
- Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297–334. <https://doi.org/10.1007/BF02310555>.
- Cunningham, J., Paradies, Y.C., 2012. Socio-demographic factors and psychological distress in indigenous and non-indigenous Australian adults aged 18–64 years: analysis of national survey data. *BMC Public Health* 12, 95. <https://doi.org/10.1186/1471-2458-12-95>.
- Davidian, M., 2003. Hierarchical linear models: applications and data analysis methods. *J. Am. Stat. Assoc.* 98, 767–768. <https://doi.org/10.1198/jasa.2003.s288>.
- de Lima, C.V.C., Cândido, E.L., da Silva, J.A., Albuquerque, L.V., de Menezes Soares, L., do Nascimento, M.M., ... Neto, M.L.R., 2020. Effects of quarantine on mental health of populations affected by Covid-19. *J. Affect. Disord.* 275, 253–254. <https://doi.org/10.1016/j.jad.2020.06.063>.
- Francis, J., Wood, L.J., Knuiman, M., Giles-Corti, B., 2012. Quality or quantity? Exploring the relationship between public open space attributes and mental health in Perth, Western Australia. *Sociol. Sci.* 74, 1570–1577. <https://doi.org/10.1016/j.socscimed.2012.01.032>.
- Fushimi, M., Saito, S., Shimizu, T., Kudo, Y., Seki, M., Murata, K., 2012. Prevalence of psychological distress, as measured by the Kessler 6 (K6), and related factors in Japanese employees. *Community Ment. Health J.* 48, 328–335. <https://doi.org/10.1007/s10597-011-9416-7>.
- George, D., Mallery, M., 2003. *SPSS for Windows Step by Step: A Simple Guide and Reference 14.0 (Seventh Edition)*, Pearson, London.
- Hawryluck, L., Gold, W.L., Robinson, S., Pogorski, S., Galea, S., Styra, R., 2004. SARS control and psychological effects of quarantine, Toronto, Canada. *Emerg. Infect. Dis.* 10, 1206. <https://doi.org/10.3201/eid1007.030703>.
- Hill, T.D., Burdette, A.M., Hale, L., 2009. Neighborhood disorder, sleep quality, and psychological distress: testing a model of structural amplification. *Health Place* 15, 1006–1013. <https://doi.org/10.1016/j.healthplace.2009.04.001>.
- Hung, L.S., 2003. The SARS epidemic in Hong Kong: what lessons have we learned? *J. R. Soc. Med.* 96, 374–378. <https://doi.org/10.1258/jrsm.96.8.374>.
- Jiang, S., Xia, S., Ying, T., Lu, L., 2020. A novel coronavirus (2019-nCoV) causing pneumonia-associated respiratory syndrome. *Cellular Molecular Immunology*, 1–1. <https://doi.org/10.1038/s41423-020-0372-4>.
- Kawachi, I., Berkman, L.F., 2003. *Neighborhoods and Health*. Oxford University Press, Oxford.
- Kessler, R.C., Andrews, G., Colpe, L.J., Hiripi, E., Mroczek, D.K., Normand, S.-L., Walters, E.E., Zaslavsky, A.M., 2002. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychol. Med.* 32, 959–976. <https://doi.org/10.1017/S0033291702006074>.
- Krasnik, A., Fouchard, J.R., Bayer, T., Keiding, N., 1990. Health workers and AIDS: knowledge, attitudes and experiences as determinants of anxiety. *Scand. J. Soc. Med.* 18, 103–113. <https://doi.org/10.1177/140349489001800204>.
- Lau, J., Yang, X., Tsui, H., Kim, J., 2003. Monitoring community responses to the SARS epidemic in Hong Kong: from day 10 to day 62. *J. Epidemiol. Community Health* 57, 864–870. <https://doi.org/10.1136/jech.57.11.864>.
- Lau, J.T., Yang, X., Pang, E., Tsui, H., Wong, E., Wing, Y.K., 2005. SARS-related perceptions in Hong Kong. *Emerg. Infect. Dis.* 11, 417. <https://doi.org/10.3201/eid1103.040675>.
- Lawrence, D., Mitrou, F., Zubrick, S.R., 2011. Non-specific psychological distress, smoking status and smoking cessation: United States National Health Interview Survey 2005. *BMC Public Health* 11, 256. <https://doi.org/10.1186/1471-2458-11-256>.
- Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., Ren, R., Leung, K.S., Lau, E.H., Wong, J.Y., 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N. Engl. J. Med.* <https://doi.org/10.1056/NEJMoa2001316>.
- Lincoln, K.D., Taylor, R.J., Chae, D.H., Chatters, L.M., 2010. Demographic correlates of psychological well-being and distress among older African Americans and Caribbean Black adults. *Best Pract. Ment. Health* 6, 103.
- Marchand, A., Demers, A., Durand, P., Simard, M., 2003. Occupational variations in drinking and psychological distress: a multilevel analysis. *Work* 21, 153–163.
- Matthews, S.A., Yang, T.C., 2010. Exploring the role of the built and social neighborhood environment in moderating stress and health. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine* 39, 170–183. <https://doi.org/10.1007/s12160-010-9175-7>.
- Mazza, C., Ricci, E., Biondi, S., Colasanti, M., Ferracuti, S., Napoli, C., & Roma, P., 2020. A nationwide survey of psychological distress among Italian people during the COVID-19 pandemic: immediate psychological responses and associated factors. *International Journal of Environmental Research and Public Health* 17, 3165. doi:<https://doi.org/10.3390/ijerph17093165>.
- Meerlo, P., Sgoifo, A., Suchecki, D., 2008. Restricted and disrupted sleep: effects on autonomic function, neuroendocrine stress systems and stress reactivity. *Sleep Med. Rev.* 12, 197–210. <https://doi.org/10.1016/j.smrv.2007.07.007>.
- Myhren, H., Ekeberg, Ø., Stokland, O., 2011. Satisfaction with communication in ICU patients and relatives: comparisons with medical staffs' expectations and the relationship with psychological distress. *Patient Educ. Couns.* 85, 237–244. <https://doi.org/10.1016/j.pec.2010.11.005>.
- Norhouse, L.L., Templin, T., Mood, D., Oberst, M., 1998. Couples' adjustment to breast cancer and benign breast disease: a longitudinal analysis. *Psycho-Oncology* 7, 37–48. [https://doi.org/10.1002/\(SICI\)1099-1611\(199801/02\)7:1<37::AID-PON314>3.0.CO;2-3](https://doi.org/10.1002/(SICI)1099-1611(199801/02)7:1<37::AID-PON314>3.0.CO;2-3).
- Nunnally, J.C., 1994. *Psychometric Theory 3E*. Tata McGraw-Hill Education, New York.
- Reynolds, D., Garay, J., Deamond, S., Moran, M., Gold, W., Styra, R., 2008. Understanding, compliance and psychological impact of the SARS quarantine experience. *Epidemiol. Infect.* 136, 997–1007. <https://doi.org/10.1017/S0950268807009156>.
- Rocha, K., Pérez, K., Rodríguez-Sanz, M., Obiols, J.E., Borrell, C., 2012. Perception of environmental problems and common mental disorders (CMD). *Soc. Psychiatry Psychiatr. Epidemiol.* 47, 1675–1684. <https://doi.org/10.1007/s00127-012-0474-0>.
- Roma, P., Monaro, M., Muzi, L., Colasanti, M., Ricci, E., Biondi, S., ... Mazza, C., 2020. How to Improve Compliance with Protective Health Measures during the COVID-19 Outbreak: Testing a Moderated Mediation Model and Machine Learning Algorithms. *International journal of environmental research and public health* 17, 7252. <https://doi.org/10.3390/ijerph17197252>.
- Shiller, R.J., 2020. COVID-19 has brought about a second pandemic: financial anxiety. *Retrieved August 29, 2020*.
- Sooman, A., Macintyre, S., 1995. Health and perceptions of the local environment in socially contrasting neighbourhoods in Glasgow. *Health Place* 1, 15–26.
- Swanson, V., Sharpe, T., Porteous, C., Hunter, C., Shearer, D., 2016. Indoor annual sunshine opportunity in domestic dwellings may predict well-being in urban residents in Scotland. *Ecopsychology* 8, 121–130. <https://doi.org/10.1089/eco.2015.0059>.
- Talala, K., Huurre, T., Aro, H., Martelin, T., Prättälä, R., 2008. Socio-demographic differences in self-reported psychological distress among 25- to 64-year-old Finns. *Soc. Indic. Res.* 86, 323–335. <https://doi.org/10.1007/s11205-007-9153-z>.
- The Globe and Mail, 2020. 'Eat, sleep and play on your phone': in remotest parts of China, coronavirus lockdown shutters shops and cuts off supplies. <https://www.theglobeandmail.com/world/article-eat-sleep-and-play-on-your-phone-in-remotest-parts-of-china/>. Accessed March 22, 2020.
- The New York Times, 2020. To tame coronavirus, Mao-style social control blankets China. <https://www.nytimes.com/2020/02/15/business/china-coronavirus-lockdown.html>. Accessed March 22, 2020.
- Turner, J., Kelly, B., 2000. Emotional dimensions of chronic disease. *West. J. Med.* 172, 124. <https://doi.org/10.1136/ewj.172.2.124>.
- Van den Berg, A.E., Maas, J., Verheij, R.A., Groenewegen, P.P., 2010. Green space as a buffer between stressful life events and health. *Soc. Sci. Med.* 70, 1203–1210. <https://doi.org/10.1016/j.socscimed.2010.01.002>.
- Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C. S., & Ho, R. C., 2020a. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *International Journal of Environmental Research and Public Health* 17, 1729. doi:<https://doi.org/10.3390/ijerph17051729>.
- Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., McIntyre, R.S., ... Ho, C., 2020b. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain, Behavior, and Immunity*. <https://doi.org/10.1016/j.bbi.2020.04.028>.
- Wen, M., Hawkey, L.C., Cacioppo, J.T., 2006. Objective and perceived neighborhood environment, individual SES and psychosocial factors and self-rated health: An analysis of older adults in Cook County, Illinois. *Soc. Sci. Med.* 63 (10), 2575–2590.
- Weyerer, S., Kupfer, B., 1994. Physical exercise and psychological health. *Sports Med.* 17, 108–116. <https://doi.org/10.2165/00007256-199417020-00003>.
- Zhang, X., Wargocki, P., Lian, Z., Thyregod, C., 2017. Effects of exposure to carbon dioxide and bioeffluents on perceived air quality, self-assessed acute health symptoms, and cognitive performance. *Indoor Air* 27, 47–64. <https://doi.org/10.1111/ina.12284>.
- Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., 2020. A novel coronavirus from patients with pneumonia in China, 2019. *N. Engl. J. Med.* <https://doi.org/10.1056/NEJMoa2001017>.