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Received 24 May 2020; revised 19 June 2020; accepted 2 July 2020.

## Geographical identification of the vulnerable groups during COVID-19 crisis: Psychological typhoon eye theory and its boundary conditions

doi:10.1111/pcn.13114

COVID-19 has been reducing people's well-being, as shown by a rapid increase in people's burnout or distress across different countries.<sup>1,2</sup> Many mental health services aim to help people at the epicenter, following the principle of the 'ripple effect'<sup>3</sup> as in the epidemics of severe acute respiratory syndrome and Ebola.<sup>4,5</sup> Yet, drawing from psychological typhoon eye theory,<sup>6–8</sup> the unprecedented scale of the COVID-19 pandemic prompts us to suspect that individuals' well-being might deteriorate over their distance from the epicenter (i.e., the center of an epidemic area). Identifying the vulnerable regions where individuals are more likely to suffer from well-being issues helps direct attention towards the more vulnerable groups during an ongoing pandemic.

To help better screen for such vulnerable groups of people during the COVID-19 crisis, we examine typhoon eye theory and at which conditions it is useful. Specifically, we submit that the typhoon effect was useful among younger adults and those with a certain family status.

We sent a survey to 410 working adults staying in various cities in China during 20–21 February 2020.<sup>9,10</sup> The survey assessed their sex,

age, education, family status, job status, location, and the Satisfaction With Life Scale. Among the 308 of those who responded, we used their locations to calculate their distance to Wuhan, the COVID-19 epicenter in China, ranging from 0 to 2126 km. We used multiple linear regression to predict life satisfaction (Table 1).

Women experienced higher life satisfaction than did men ( $\beta = 0.30$ , 95% confidence interval [CI], 0.15 to 0.45;  $P < 0.001$ ). Adults who worked from home ( $\beta = -0.23$ , 95%CI,  $-0.42$  to  $0.04$ ;  $P = 0.018$ ) or had their work suspended during COVID-19 ( $\beta = -0.36$ , 95%CI,  $-0.56$  to  $-0.16$ ;  $P < 0.001$ ) were less satisfied than those who continued working in their workplace.

The association between the distance to the epicenter and life satisfaction depended on age and family status. As illustrated in Figure S1a, this association was less negative among the older adults ( $\beta = 0.02$ , 95%CI, 0.001 to 0.04;  $P = 0.033$ ). Margin analysis shows that the coefficients were significantly negative for those aged 20 years ( $\beta = -0.60$ , 95%CI,  $-1.05$  to  $-0.14$ ;  $P = 0.011$ ), 30 years ( $\beta = -0.41$ , 95%CI,  $-0.73$  to  $-0.09$ ;  $P = 0.011$ ), and 40 years ( $\beta = -0.22$ , 95%CI,  $-0.45$  to  $<0.00$ ;  $P = 0.048$ ). The association was not significant for those aged 50 years or above.

The negative association between the distance to the epicenter and life satisfaction also depended on family status, as illustrated in Figure S1b. The negative association (i.e., the typhoon eye effect) was significant among singles ( $\beta = -0.47$ , 95%CI,  $-0.92$  to  $-0.17$ ;  $P = 0.042$ ) and those married with one child ( $\beta = -0.42$ , 95%CI,  $-0.72$  to  $-0.12$ ;  $P = 0.006$ ). The association between the distance to the epicenter and life satisfaction was positive for those who were divorced or widowed ( $\beta = 1.02$ , 95%CI, 0.51 to 1.54;  $P < 0.001$ ). The association was insignificant for the remaining groups.

Practically, our findings combine geographical and demographic information of participants to help identify vulnerable individuals. We revealed that the typhoon eye effect (i.e., the further people are away from the epicenter, the lower their life satisfaction) was significant only for adults who were younger or had smaller families. Our results suggest that mental health services cannot use the typhoon eye effect as the only geographical information to identify those with low life satisfaction.

This study focuses on a single epicenter, which is often but not always the case for an epidemic. Wuhan was the clear epicenter of COVID-19 in China. Yet, South Korea simultaneously had several epicenters. Future research may explore epidemics with multiple epicenters, exploring the effect of the minimum, median, maximum, or average (weighted by cases) distance from multiple epicenters.

In sum, this study provides insights on using typhoon eye theory and its boundary conditions to identify people more vulnerable to well-being impairment during the COVID-19 pandemic. Our research calls for a more nuanced understanding of how to use geographical and demographic information to identify vulnerable individuals during the COVID-19 pandemic.

### Acknowledgment

The data collection was funded by the Chinese National Funding of Social Sciences (Grant number: 1509093).

### Disclosure statement

All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; and no other relationships or activities that could appear to have influenced the submitted work. The authors declare that they have no competing interests.

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**Table 1** Life satisfaction by sex, age, education, family status, marriage status, and the distance to the epicenter

Variables	No. (%) or Mean ± SD	Parameter estimates (95%CI)	P-value
<b>Sex</b>			
Male	168 (54.5%)	Reference	
Female	140 (45.5%)	0.300 (0.146 to 0.453)	<0.001
Age (years)	38.50 ± 9.26	-0.005 (-0.027 to 0.018)	0.676
<b>Family status</b>			
Single	171 (32.3%)	Reference	
Married without children	15 (2.8%)	-0.232 (-1.095 to 0.630)	0.596
Married with one child	177 (33.5%)	-0.355 (-0.289 to 1.000)	0.279
Married with more than one child	150 (28.4%)	0.123 (-0.579 to 0.824)	0.731
Divorced/widowed	16 (3.0%)	-1.238 (-1.864 to -0.611)	<0.001
<b>Education</b>			
Elementary school	4 (1.3%)	Reference	
Middle school	31 (10.1%)	0.091 (-0.532 to 0.714)	0.774
High school	39 (12.7%)	0.149 (-0.457 to 0.754)	0.630
Vocational school	55 (17.9%)	0.287 (-0.331 to 0.906)	0.361
Bachelor	119 (38.6%)	0.104 (-0.508 to 0.717)	0.738
Master	49 (15.9%)	0.315 (-0.313 to 0.943)	0.324
Doctorate	11 (3.6%)	0.546 (-0.134 to 1.227)	0.115
<b>Job status</b>			
Usual work routine	99 (32.1%)	Reference	
Home office	132 (42.9%)	-0.231 (-0.422 to -0.039)	0.018
Work suspended	77 (25.0%)	-0.361 (-0.561 to -0.161)	<0.001
Distance to the epicenter (in 1000 km)	0.81 ± 0.41	-1.138 (-1.919 to -0.357)	0.004
Distance to the epicenter × Age		0.019 (0.001 to 0.036)	0.033
Distance to the epicenter × Family status		Reference	
Distance to the epicenter × Single		Reference	
Distance to the epicenter × Married without children		0.826 (-0.110 to 1.761)	0.084
Distance to the epicenter × Married with one child		0.047 (-0.511 to 0.605)	0.868
Distance to the epicenter × Married with more than one child		0.346 (-0.363 to 1.055)	0.338
Distance to the epicenter × Others (e.g., divorced/widowed)		1.492 (0.825 to 2.160)	<0.001


CI, confidence interval.

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**Supporting information**

Additional Supporting Information may be found in the online version of this article at the publisher’s web-site:

**Figure S1.** (a) Association between distance to the epicenter and life satisfaction by individual’s age. (b) The association between distance to the epicenter and life satisfaction by individual’s family status.

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Received 7 May 2020; revised 27 June 2020; accepted 9 July 2020.