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Assessing the effectiveness and pathways of planned shelters in protecting mental health of flood victims in China

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Abstract

Background. Evacuation and sheltering are commonly used strategies for disaster risk reduction and climate change adaptation, but may negatively affect mental health of internally displaced persons (IDPs). Recently, Chinese governments have developed planned settlements providing integrated and intensive health services and environmental interventions to reduce immediate disastrous impacts and support the mental health of IDPs. *Methods.* Here we selected 69 planned shelters by stratified sampling to describe the implemented interventions conducted in Anhui Province of China after the 2016 severe floods, and we used standardized psychological scales to survey the intervention group (IDP who lived in these planned shelters) and the matched control group (victims living in their homes). Multivariable logistic regression was used to examine the association between social-demographic characteristics, flooding exposure, environmental conditions and the psychological diseases. Adjusted odds ratios (ORs) were calculated to compare their prevalence of psychological diseases, and to identify its influencing factors though comparing multiple interventions. Finally, the structural equation modeling was used to identify their influencing pathways. *Results.* Compared with the control group, the intervention group had a significantly lower risk of anxiety (OR = 0.36; 95% CI: 0.18–0.71), depression (OR = 0.36; 95% CI: 0.19–0.68) and post-traumatic stress disorder (OR = 0.29; 95% CI: 0.15–0.56). Environmental interventions providing clean water, safe food, environmental hygiene, risk communication and sufficient accommodation had a protective effect (standardized indirect effect = −0.153, $p < 0.01$) on the risk of psychological problems, mediating the negative effect caused by displacement and sheltering. *Conclusions.* How planned shelters were used to achieve better mental health outcomes in Anhui could inform other flood-prone areas to mitigate psychological vulnerability of IDPs.

1. Introduction

Among all natural disasters related to climate change, flooding is one of the leading causes of fatalities (Doocy *et al* 2013), and could significantly induce negative health impacts on a large population including not only epidemics of infectious diseases but also non-communicable diseases and psychological pressures (Norris *et al* 2002, Alderman *et al* 2012). In order to reduce health risks from floods and other natural hazards, mass evacuation and sheltering have been used as common strategies of short-term displacement to provide temporary settlement to internally displaced persons (IDPs) and ultimately reduce

injuries and fatalities (Global CCCM Cluster 2014, Wu *et al* 2019). Between 2008 and 2013, displacement to temporary shelters has been globally used to evacuate 27 million people per year on average (Global CCCM Cluster 2014). As climate change will increase the frequency, intensity and severity of extreme weather events (Global CCCM Cluster 2014, IPCC 2012, UN Regugee Agency 2015), a larger scale of displacement may occur more frequently in the future, especially to those climate-sensitive nations facing with rapid urbanization and exponential growth of population (Uscherpines 2009, UN Regugee Agency 2014).

The displacement caused by evacuation and sheltering can be regarded as a disturbance that may worsen IDPs' mental health conditions (Munro *et al* 2017). Previous studies found that disaster displacement could exacerbate psychological distress among IDPs, whereby people who were displaced to an unplanned settlement were found to have a higher prevalence of negative psychological symptoms such as anxiety, depression and post-traumatic stress disorder (PTSD) than those who stayed at their original locations of residence (Porter and Haslam 2001, 2005, Reed *et al* 2011, Fussell and Lowe 2014, Munro *et al* 2017). These studies have discussed multiple potential pathways of displacement and resettlement that may negatively affect mental health, including destroying social ties (Porter 2001, Porter and Haslam 2005, Reed *et al* 2011), environmental degradation (Fussell and Lowe 2014), housing instability (Porter 2001, Reed *et al* 2011, Munro *et al* 2017), alteration of daily routines and mobility (Porter and Haslam 2005, Uscherpines 2009), as well as insufficient living conditions due to socioeconomic burden and low livability (Porter and Haslam 2005, Fussell and Lowe 2014).

In order to minimize the negative effect from informal resettlement, an innovative concept of 'planned relocation' has recently been promoted, which refers to both temporary relocation as disaster response and permanent relocation for climate-sensitive areas (UN Regugee Agency 2014). However, permanent relocation is a measure of last resort while temporary relocation is a more frequently used strategy (UN Regugee Agency 2015). Specifically for temporary relocation, planned sheltering usually include both mass evacuation and resettlement process (Global CCCM Cluster 2014), which are pre-designated or purpose-built as disaster-resilient infrastructure to mitigate health risks of IDPs. It suggested that the government should apply a top-down strategy to develop planned settlement with facilities that are not only able to reduce immediate disastrous impacts during the post-disaster period, but also support victims by long-term mitigating their disease burden and socio-psychological risk (UN Regugee Agency 2014, 2015). The planned shelters are actually community centers that provide integrated and intensive health services and environmental

interventions through the co-operation of multiple agencies (Global CCCM Cluster 2014, Wu *et al* 2019).

Although previous studies have highlighted the importance of effective and planned sheltering that may reduce mental health vulnerability (Porter and Haslam 2005, Fussell and Lowe 2014), these studies did not examine the effect of planned sheltering on mental health. Also various environmental interventions have been implemented in the disaster shelters, so as to improve victims' living conditions to reduce their risk of acquiring infectious diseases and improve their physical health (Porter and Haslam 2005, Alderman *et al* 2012). However, few research has focused on the mental health effect attributed to these implemented interventions, let alone to identify any causal evidence regarding any protective effect of these environmental interventions on mental health of IDPs.

In China, the government has established planned shelters and implemented various strategies for the affected populations who were displaced from disaster zones during the post-disaster period. According to the 2016 Yearbook of Meteorological Disasters in Anhui Province, a catastrophic flood event occurred in June 2016 resulted from at least 20 continuous days of rain with a cumulative precipitation of 700 mm across the Yangtze River basin. This was China's most severe flood event since 1998. The high occurrence of flash floods led to a total of 73 districts within 11 cities as flooding zones across the whole Anhui Province in China. There were more than 50 000 houses collapsed, 72 000 houses seriously ruined, and 139 000 houses mildly damaged across the province during this event. We selected the case scenario in Anhui Province, the region most greatly impacted by the flood, where approximately 8.4 million people were affected, including 80 000 persons who were evacuated and displaced to a new location. The provincial government forced mass evacuations pre-flood and established 492 planned shelters in pre-designated facilities, with a maximum capacity for 53 000 flooding victims, which accounted for over 60% of all the IDPs. These planned shelters in Anhui were different to previous informal sheltering, as they were assigned in pre-designated facilities such as schools and supported with intensive health services and environmental interventions through sufficient management as well as personnel and government support (Wu *et al* 2019). Compared with the health status after the similar flood event that occurred in 2013, in 2016 there were lower risk of reported health problems associated with infectious diseases among the victims, such as resulting in lower infectious diarrheal disease risk (Zhang *et al* 2019). Although researchers suggested that the interventions designed to improve environmental and living conditions may also reduce impacts of displacement on mental health (Porter and Haslam 2005), the effectiveness

of these measures in disaster relief shelters remains unknown.

Thus, this study aimed to analyze the pathways of planned shelters in affecting mental health of flood victims using a cross-control design in post-disaster scenario of the 2016 severe flood event in Anhui Province. The specific objectives included: Firstly, to identify the interventions implemented in the 69 planned shelters and extracted an integrated health management framework (IHMF); Secondly, to compare the psychological status of the flood IDPs who lived in planned shelters, and the matched group of victims who lived in their original homes; Finally, to further examine the potential mechanism of planned shelters on mental health, so as to test whether there is any mediating effect of interventions between the planned sheltering and mental health conditions.

2. Methods

2.1. Study design

A two-phase field investigation was conducted based on the sampled planned shelters. For the first phase, we implemented a shelter-level investigation to evaluate the IHMF conducted in the planned shelters. This was conducted one month after the mass evacuation and shelter had been set up. In addition, the 'Rapid Health Assessment Toolkit for Public Health Impacts and Needs after Natural Disaster,' developed by the China Center for Disease Prevention and Control (CDC) and World Health Organization (WHO), was utilized to investigate the health and environmental conditions of these sampled shelters. Health Bureau Officers, who took the health management responsibilities of these planned shelters, were invited to complete all components of the shelter-level questionnaire.

For the second phase, we distributed an individual-level questionnaire survey within the sampled shelters before the victims gradually withdrawn from the shelters in September 2016. We used a cross-sectional study design, considering the planned shelters and related integrated health management strategies as the policy intervention, so as to compare the mental health conditions of the intervention group who lived in the shelters and the control group of flood victims who lived in their own homes. In this study, the Anhui government displaced and resettled the flood victims of the whole community where assessed as the high flooding risk areas. As a result, the control groups were chosen as those non-displaced victims who were still living in their own homes in the communities that were most closed to the original home addresses of the intervention groups, so as to match these two groups by eliminating regional differences.

All respondents were surveyed on-site visiting by our investigators who were with training, so as to assistant the victims' completion of the questionnaires, including explained questions to the victims when they did not understand, read questionnaires for the elderly, asked for a signed consent form with an agreement to participate in the study and etc. Additionally, to avoid the possibility that people would respond differently because they were in a government-operated facility compared with living in their own homes, our investigators explained that our questionnaire was anonymous and not directly linked to government subsidies or any other supports.

Our individual respondents were defined as victims of the 2016 flood event over 16 years old and reported to be affected by the flash floods in any terms of house damage, property loss, personal injury, or death(s) or injuries of at least a relative. Only aggregated data was used and participants will remain anonymous, and Sun Yat-Sen University has provided guidelines for this study procedures. Additionally, the datasets collected and analyzed during the current study are available from the corresponding author on reasonable request.

Additionally, to explore the potential mechanisms of sheltering on mental health, we established several basic hypothetical models to identify any mediating effect of multiple policy interventions (e.g. social support, living support, health care, and environmental conditions) between the planned sheltering and mental health conditions, based on the previous studies (Wu *et al* 2019, Fussell and Lowe 2014, Zhong *et al* 2018).

2.2. Sampling methods

In 2016 Anhui province, most of the displacement and sheltering were spatially clustered in the high flooding risk areas. Therefore, the study identified four cities as the study districts due to severity of the flood and concentration of mass shelters, including Lu An, Wu Hu, Xuan Cheng and An Qing. First, we pre-selected 80 planned shelters through stratified sampling from eight counties of the four cities, as the planned shelters were resettled as entire communities and thus were spatially concentrated in these counties. As a result, 69 sampled shelters returned the well-validated questionnaires. There were less than 10% missing data of all the indicators due to incomplete questionnaires, thus the dataset was still valid and useable according to previous studies (Cheema 2014). These 69 shelters supported at least 13 500 displaced victims, which accommodated approximately a quarter of all the IDPs in the planned shelters of Anhui Province.

Then, we used proportional random sampling method to pre-select one-twentieth of the IDPs who lived in the 69 shelters (n = 675), and their home addresses were retrieved based on their registered record from their corresponding shelter. A total of 665 sampled IDPs who lived in the 69 flood shelters (intervention group) were screened as flood victims

and surveyed, and 338 of them completed the questionnaire, for a response rate of 52.4%. We also surveyed 750 victims who did not live in the shelters but lived in their own homes (controls). The victims of control group were identified who were living close to the original residence addresses of the intervention group based on our registration records of the shelters. For the control group, 327 of these victims fully completed the questionnaire, with a response rate of 43.6%. To reduce the response bias that victims in a poor emotional status could be more likely to refuse to answer questions, our investigators also asked the reasons of victims who refused to be surveyed, and found that most victims in both groups refused to be surveyed because they were busy repairing their original houses without sufficient time.

As a result, a total of 665 questionnaires were returned, including the intervention group who lived in these sampled shelters (n = 338), and the matched control group of non-shelters due to a low-risk condition defined by the government sectors (n = 327). Our validated sample of flood victims is bigger than the median number of previous displacement studies (the median sample of 56 studies is 164) (Porter and Haslam 2005).

2.3. Measuring mental health outcomes
Our questionnaire included the following instruments and question measures: socio-demographic characteristics, flood exposure, their living conditions and accessible environmental interventions, acceptance of psychological counselling, acceptance of social support, and psychological self-assessment scales.

We used three different kinds of standardized psychological scales to survey the intervention group and the matched control group. Specifically, we used the PCL-C-17 scale (PTSD checklist-Civilian Version) to evaluate the PTSD of each respondent by asking the respondents to indicated how much they have been bothered by each symptoms in past month with a 5-point scale (not at all, a little bit, moderately, quite a bit, and extremely) (Andrykowski *et al* 1998; Hu *et al* 2015). Moreover, the 20-items self-rating anxiety scale (SAS-20) and the 20-items self-rating depression scale (SDS-20) were used to evaluate anxiety and depression by asking the respondents how often they felt and behaved this way in the past month using a 4-point scale (a little of the time, some of the time, good part of the time, and most of the time) (McDowell 2006). These psychological self-assessment scales have generally been used in mental health measurement after disasters and were tested to have good validity and reliability (Porter and Haslam 2005, Zhong *et al* 2018), as well as have been translated into Chinese versions by the World Health Organization and validated in Chinese studies (Xu *et al* 2013, Hu *et al* 2015). In order to confirm the psychological scales, Cronbach's alpha coefficient was

separately calculated for the items of SAS, SDS, and PCL-C, with coefficients of 0.895, 0.899, and 0.894. All the coefficients of at least 0.8 suggest great consistency in the index.

2.4. Statistical analyses
In this study, we first applied a descriptive analysis to characterize the shelter-level data by estimating the percentage of health and environmental interventions implemented in the selected planned shelters. We have grouped the health and environmental interventions into seven dimensions based on *the Guidelines of Health Emergency Work for Natural Disaster* developed by Chinese CDC.

We then analyzed and compared the relationship between social-demographic characteristics, flood exposure, environmental conditions and prevalence of psychological disorders between victims from the intervention group and the control group based on individual-level data and a multivariate logistic regression. We used a descriptive analysis to descript the percentages and numbers of these essential statistics in the intervention group and the control group. Also we selected independent variables based on a systematic literature review of the previous studies (Zhong *et al* 2018). The variance inflation factor (VIF) was used to examine on collinearity effects of independent variables. All the VIF were less than 5, therefore there was no multicollinearity problem. Additionally, adjusted odds ratios (ORs) were calculated to estimate the impact of planned sheltering on mental health, controlling for covaribles of sex, age, profession, education, marital status, annual income, injury, house damage, and family economic loss as previous studies (Porter and Haslam 2005, Zhong *et al* 2018).

Our study hypothesized a mediating effect of multiple policy interventions between sheltering and mental illnesses based on the previous descriptive studies (Wu *et al* 2019, Fussell and Lowe 2014), which was illustrated in figure 1 with the 'uncertainty effect' of environmental interventions on mental health. Structural equation modeling (SEM) is suitable for exploring pathways that are with multiple causes and multiple outcomes and identifying latent variables that are indirectly inferred from multiple observed variables (Byrne 2013). We test the hypothesis and analyze the influential pathways and the standardized effect of planned shelters on mental health using SEM, and Mplus 7.4 was used to conduct SEM (Byrne 2013). In this study, the multiple policy interventions (e.g. social support, living support, health care and environmental conditions) and mental illness were used as latent variables.

Before conducting the SEM, we tested the correlation between the environmental interventions to avoid high correlation between variables (Byrne 2013). However, the provided environmental interventions were based on the concept of

'planned shelter', as such an integrated intervention strategy was applied so this study allows the intervention variables to be related to some extent in the model.

The SEM has two models including measurement model and structural model (Byrne 2013). Firstly we used the measurement model to conduct the categorical confirmatory factor analysis (CCFA) to test the construct validity of our proposed model, including whether the latent variable of integrated environmental interventions could be represented by the selected observed variables of clean domestic water, clean drinking water, safety food, environmental hygiene, accommodation and risk communication. And whether the latent variables of mental disorders could be represented by the selected observed variables of anxiety, depression and PTSD. We test the consistency reliability (coefficients: composite reliability), convergent validity (coefficients: factor loading) and discriminant validity (coefficients: average variance extracted) of the constructs in our proposed model, the CCFA using weighted least squares mean and variance (WLSMV) estimator was employed, as this method performs better than other estimation methods when dealing with category data (Beauducel and Herzberg 2006).

Alternatively, we tested other potential mechanisms that there is a mediating effect of interventions related to acceptance of social support (i.e. the relatives and friends support, local government support, and health care support) between the sheltering and mental illnesses, based on the previous studies (Xu *et al* 2013, Dai *et al* 2016a, 2016b, Mcguire *et al* 2018).

Then, we performed the structural model to test our hypothetical model that mediating effect of any interventions exist between planned sheltering and mental health. Bootstrapping was performed at a 99% confidence interval with 10 000 resampled sets, to test for indirect effects without imposing an assumption of normality in the sampling distribution (Hayes 2009). The structural model was confirmed using two classes of fit indices: incremental fit, and absolute fit. An incremental fit index, including comparative fit index (CFI) and Tucker–Lewis incremental fit index (TLI), is analogous to R^2 and so a value of zero indicates having the worst possible model and a value of one indicates having the best possible (Iacobucci 2010). The measure of absolute fit (RMSEA) determines how far the model is from perfect fit. We evaluated fit of the data, using the TLI, CFI, and root mean square error of approximation (RMSEA). CFI and TLI greater than .90 were regarded as a good fit to the data and an RMSEA with values of less than .08 indicated an adequate fit to the data (Jackson *et al* 2009). Only findings from the final validated structural equation model are presented in the results. All data analysis was performed using software of SPSS 24.0 and Mplus 7.4.
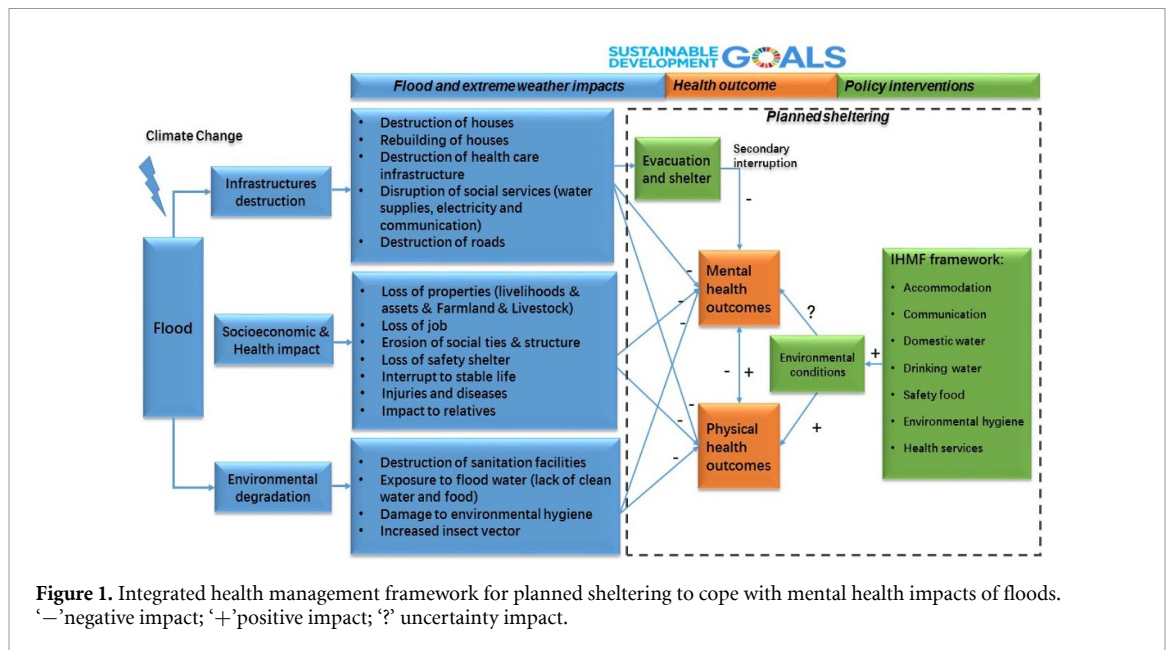
3. Results

3.1. Integrated Health Management Framework (IHMF)

We have extracted an IHMF based on *the Guidelines of Health Emergency Work for Natural Disaster* developed by Chinese CDC, which are consistent with the international guidance for planning mass evacuation and relocation to cope with disasters (Global CCCM Cluster 2014, UN Regugee Agency 2015). Our established IHMF has identified and categorized seven dimensions of health and environmental interventions implemented in the planned shelters including: conditions of accommodation, drinking water, food safety, toilet hygiene, environmental sanitation, medical services, and public health services.

Additionally, we have extracted a conceptual framework through literature reviews and previous studies (Fussell and Lowe 2014, Warsini *et al* 2014, Zhong *et al* 2018, Wu *et al* 2019,), so as to guide the subsequent analysis of our quantitative results. Figure 1 shows the complex interactions among the flood impacts, mental health outcomes, and integrated policy interventions of planned sheltering. As flooding can cause tremendous stresses from infrastructure destruction, socioeconomic disruptions and environmental degradation (Fussell and Lowe 2014, Warsini *et al* 2014, Zhong *et al* 2018, Wu *et al* 2019), all these stresses, individually or in combination, can cause victims to suffer negative health outcomes including mental illness, physiological diseases and their interaction(s) (Hu *et al* 2015, Zhong *et al* 2018), but the environmental interventions may have a positive impact on mental health outcomes (Porter and Haslam 2005, Zhong *et al* 2018).

As shown in table 1, under these seven dimensions of IHMF, 44 indicators were extracted and the implemented standards were described in our previous qualitative study (Wu *et al* 2019). The conditions of health and environmental implementations among 69 sampled planned shelters based on all 44 indicators show that, most planned shelters met the basic standard of all dimensions related to environmental interventions. However, public health services (e.g. registering and management of patients with severe mental illness) of several planned shelters did not meet the basic requirements.

For individual-level investigation, there were a higher percentage of older adults and low-income victims in the intervention group than the control group (table 2). In addition, a larger percentage of victims in the intervention group reported damage to their original home compared to the control group. Victims from the planned shelters generally reported higher accessibility of multiple environmental interventions (e.g. clean domestic water, safe drinking water, safety food, clean toilet, garbage and environmental hygiene, sufficient accommodation and risk communication), compared to victims

Figure 1. Integrated health management framework for planned sheltering to cope with mental health impacts of floods. '−'negative impact; '+'positive impact; '?' uncertainty impact.

from the control group who reported lower accessibility. For mental health counselling, only a few victims from both the intervention group (15.4%) and the control group (15.6%) received care, resulting in an insignificant difference between these two groups.

3.2. Protective effect of planned sheltering on mental health

Victims living in the planned shelters (intervention group) had a significantly lower percentage of anxiety (16%) and PTSD (16%) than those in the control group (anxiety 35%; PTSD 38%), adjusting for all covariates listed in table 3 (i.e. sex, age, profession, education, marital status, annual income, injury, house damage and family economic loss). Figure 2 revealed that victims from the intervention group had a significantly lower risk of self-reported anxiety (OR = 0.34; 95% CI: 0.22–0.55), depression (OR = 0.60; 95% CI: 0.40–0.90), and PTSD (OR = 0.26; 95% CI: 0.16–0.42), compared to the control group.

3.3. The potential mechanism of planned sheltering effect on mental health

Figure 2 indicated that victims with access to a clean environment, and sufficient accommodation living conditions had a lower risk for all selected mental disorders. Specifically, access to clean environment among the victims resulted in an OR of 0.34 (95% CI: 0.19–0.60) for reported anxiety, OR of 0.52 (95% CI: 0.29–0.92) for depression, and OR of 0.13 (95% CI: 0.07–0.25) for PTSD. Access to sufficient accommodation living conditions resulted in ORs of 0.35 (95% CI: 0.20–0.62) for anxiety, 0.54 (95% CI: 0.30–0.95) for depression, and 0.23 (95% CI: 0.12–0.42) for PTSD.

Additionally, victims with access to clean domestic water had a lower risk of PTSD (OR = 0.13,

95% CI: 0.06–0.29); having access to safe drinking water might contribute to a lower risk of self-reported anxiety (OR = 0.44; 95% CI: 0.23–0.84) and PTSD (OR = 0.16; 95% CI: 0.08–0.33); access to safe food could result in a lower risk of anxiety (OR = 0.35; 95% CI: 0.18–0.68) and PTSD (OR = 0.08; 95% CI: 0.03–0.17); and access to risk communication (e.g. mobile text messages, local media release, and household notification) was associated with a significantly lower risk of anxiety (OR = 0.43; 95% CI: 0.19–0.94) and PTSD (OR = 0.28; 95% CI: 0.12–0.67). In contrast, we did not find any significant difference between those who did, and did not, receive mental health counselling.

The correlations between all environmental interventions were tested (figure 3). We found that the correlation coefficient between domestic water and drinking water was high (0.828, $p < .01$). By testing the construct validity of the SEM model with a CCFA using WLSMV -estimator (figure 3), we found a high internal consistency (composite reliability: CR > 0.6), high convergent validity ($p < .001$ for all factor loadings), and high discriminant validity (average variance extracted: AVE > 0.50) of the constructs in the model (Beauducel and Herzberg 2006). There was also a good model fit ($\chi^2/df = 4.151$, CFI = .970, TLI = .957, RMSEA = 0.070), indicating that all measures of integrated environmental interventions and mental health problems were representative.

The results of SEM also indicated a fit of the hypothesized model for the estimation of mediating effect ($\chi^2 = 122.343$, df = 32, $\chi^2/df = 3.823$, CFI = 0.962, TLI = 0.947, RMSEA ≤ 0.05). We found a significant mediating effect of environmental interventions between planned sheltering and mental health, with a standardized coefficient of −0.153 ($p < 0.01$).

Table 1. Description of the integrated health management strategy implemented in shelters during the 2016 flood event.

Accommodation condition

Indicators	In predesigned facilities	Have canteen	Have shower	Access to risk communication	Original arrangement	Permit long stay
Percentage	97.1	65.2	72.5	94.2	60.9	72.5

Drinking water safety

Indicators	Sufficient drinking water	Centralized water supply	Tap water	Bottled water	Sufficient disinfection	Able to boil water
Percentage	98.6	88.4	75.4	26.1	98.4	98.6

Food safety

Indicators	Sufficient food	Centralized food supply	From government or society	Cooked food	Pre-prepared food	Have mildew or rotten food
Percentage	92.8	86.8	75	89.7	10.3	0

Environmental sanitation (Garbage handling)

Indicators	Centralized garbage collection	Garbage containers	Garbage, timely cleared	Garbage, centralized handling or incineration	Disinfection and insecticide of garbage	Drainage ditches
Percentage	86.6	84.7	89.7	94.9	89.6	92.4

Environmental sanitation (Insect vector)

Indicators	Flies (none or few)	Mice (none or few)	Mosquito bites (none or few)	Animals	Insecticide and rodent control	Average number of flies in the shelter
Percentage	98.5	97	85.1	7.5	46.7	0.36

Toilet hygiene

Indicators	Toilet	Aqua privet	Feces, cleared timely	Slopes and discharge facilities for precipitation	Washing facilities	Disinfection and insecticide of toilet
Percentage	100	16.1	84.7	84.9	89.7	93.4

Medical services

Indicators	Medical point	Basic drug storage	Common disease treatment	Registration and reporting of infectious diseases	Symptom monitoring	Mental health counselling
Percentage	100	100	91.9	87.5	82.8	51.9

Public health services

Indicators	Health education	Child care system management	Neonatal visit	Pregnant women health services	Postpartum follow-up	Health guidance for the elderly over 65
Percentage	84.4	55.6	53.7	53.7	53.7	67.3
Indicators	Vaccination and immunization programs for children	AIDS, free anti-retroviral treatment	Tuberculosis patients, free anti-tuberculosis medication	Registering and management of patients with severe mental illness		
Percentage	48.1	25	37.7	38.2		

Specifically, a standard deviation increase in planned shelter resulted in a 0.369 higher standard deviation of environmental interventions (S.E:0.056, *P*-value < 0.001); while a standard deviation increase in environmental interventions resulted in a 0.414 lower standard deviation of mental disorders (S.E:0.083, *P*-value < 0.001), holding sheltering as a constant. However, the path between sheltering and mental disorders was not significant (standardized coefficient = −0.113, *p* > 0.05) while holding environmental interventions as a constant, indicating that sheltering could not directly influence mental conditions among IDPs without the improvement of integrated environmental interventions.

However, the results revealed that the social support including the relatives and friends support, local government support, and health care support, were not effective pathways between planned sheltering and reducing mental disorders in the SEM. Thus, only findings from the final specified structural equation model are presented in the results.

4. Discussion

Our study attempted to supply a new perspective of temporary relocation caused by extreme weather events and explore the potential mechanism for mitigating psychological impacts. Our research provides evidence that IDPs who lived in planned shelters (intervention group) had a lower prevalence of mental health problems than victims who remained in their own homes (control group). This result was

Table 2. Social-demographic characteristics, flood exposure and environmental conditions of respondents living in the intervention-group and control-group.

	Shelters group (n, %)	Non-shelters group (n, %)
Gender		
Male	154 (45.6%)	153 (46.8%)
Female	184 (54.4%)	174 (53.2%)
Age		
16–60 years old	186 (55.0%)	238 (72.8%)
>60 years old	152 (45.0%)	89 (27.2%)
Occupation		
Farmer	274 (81.1%)	228 (69.7%)
Non-farmer	64 (18.9%)	99 (30.3%)
Education		
Primary school or less	216 (63.9%)	183 (56.0%)
Middle school	72 (21.3%)	66 (20.2%)
High school or higher	50 (14.8%)	78 (23.9%)
Marital status		
Married	270 (79.9%)	275 (85.1%)
Single	34 (10.1%)	35 (10.8%)
Divorced or widowed	34 (10.1%)	13 (4.0%)
Annual income		
< ￥ 10 000	120 (35.7%)	60 (18.3%)
￥ 10 001–30 000	164 (48.8%)	117 (35.8%)
￥ 30 001–50 000	26 (7.7%)	78 (23.9%)
> ￥ 50 000	26 (7.7%)	72 (22.0%)
Flood exposure level		
House was damage	70 (20.7%)	28 (8.7%)
House was not damaged	268 (79.3%)	294 (91.3%)
With injury	14 (4.4%)	15 (4.6%)
No injury	303 (95.6%)	310 (95.4%)
Have relatives who were injured or died	6 (1.9%)	25 (7.7%)
No relatives who were injured or died	307 (98.1%)	300 (92.3%)
≤ ￥ 10 000 property loss	148 (48.1%)	136 (43.2%)
￥ 10 001–30 000 property loss	114 (37.0%)	99 (31.4%)
￥ 30 001–50 000 property loss	18 (5.8%)	46 (14.6%)
> ￥ 50 000 property loss	28 (9.1%)	34 (10.8%)
Could access to environmental interventions		
Clean Domestic Water	332 (98.2%)	285 (87.2%)
Safe Drinking Water	330 (97.6%)	277 (85.5%)
Food Safety	326 (96.4%)	282 (87.3%)
Hygiene	316 (94.0%)	256 (79.0%)
Sufficient Accommodation Condition	314 (93.5%)	260 (80.2%)
Risk Communication Channels	326 (97.0%)	297 (91.7%)
Received mental health counselling		
Received	48 (15.4%)	50 (15.6%)
No received	260 (84.4%)	275 (84.6%)
Total	**338**	**327**

inconsistent with the previous studies, which found that IDPs were associated with higher risks of depression, anxiety and PTSD than those without displacement (Munro *et al* 2017; Schwartz *et al* 2017; Porter and Haslam 2005; Campbell and Mark 2012). The protective effect and potential pathways were explored and confirmed by the SEM analysis, showing that better mental health outcomes were caused by the main difference (integrated environmental interventions) between planned shelters and informal (unplanned) settlements. This protective effect may offset the negative factors (e.g. high flood exposure and displacement disturbance) (Munro *et al* 2017; Porter and Haslam 2005; Reed *et al* 2011) that leading

to a higher prevalence of mental disorders among the sheltered IDPs. Our study also implied that the improved sense of environmental acquisition (as shown in table 2) as well as actual environmental condition (as shown in table 1) among the sheltered IDPs, was evidenced as additional protective factors, which can supplement previous studies that have stated the importance of other potential protective factors of sheltering (e.g. early warning, stable housing types, short distance from original homes, few times of displacement and close social ties) on mental health (Porter and Haslam 2005, Xu *et al* 2013, Fussell and Lowe 2014, Dai *et al* 2016a, Munro *et al* 2017). Therefore, the planned shelter should be an inclusive

Table 3. The adjusted ORs of psychological diseases distributed in different subgroups of respondents.

	Anxiety (n, %)[a]	Adjusted OR (95% CI)[b]	Depression (n, %)[a]	Adjusted OR (95% CI)[b]	PTSD (n, %)[a]	Adjusted OR (95% CI)[b]
Intervention or control groups						
Control (in homes)	115 (35%)	1	129 (39%)	1	126 (38%)	1
Intervention (in shelters)	56 (16%)	**0.34 (0.22,0.55)**	126 (37%)	**0.60 (0.40,0.90)**	56 (16%)	**0.26 (0.16,0.42)**
Gender						
Male	57 (18%)	1	102 (33%)	1	71 (23%)	1
Female	114 (31%)	**2.06 (1.32,3.19)**	153 (42%)	**1.68 (1.13,2.48)**	111 (31%)	**1.96 (1.26,3.05)**
Age						
16–60 years old	132 (31%)	1	167 (39%)	1	128 (30%)	1
>60 years old	39 (16%)	**0.36 (0.21,0.63)**	88 (36%)	0.67 (0.42,1.08)	54 (22%)	0.75 (0.44,1.26)
Occupation						
Non-farmer	40 (24%)	1	47 (28%)	1	44 (27%)	1
Farmer	131 (29%)	1.59 (0.88, 2.89)	208 (41%)	1.28 (0.74,2.21)	138 (27%)	1.09 (0.60,1.99)
Education						
Primary school or less	84 (28%)	1	124 (42%)	1	106 (27%)	1
Middle school	31 (30%)	0.89 (0.51,1.57)	42 (41%)	0.86 (0.52,1.44)	44 (32%)	1.34 (0.77,2.36)
High school or higher	28 (27%)	0.64 (0.33,1.23)	26 (25%)	**0.52 (0.28,0.95)**	32 (25%)	0.64 (0.33,1.26)
Marital status						
Married	140 (25%)	1	218 (40%)	1	161 (29%)	1
Single	20 (29%)	**2.11 (1.03,4.30)**	20 (29%)	0.78 (0.38,1.56)	13 (18%)	0.73 (0.33,1.61)
Divorced or widowed	9 (19%)	1.71 (0.69,4.23)	15 (31%)	1.18 (0.55,2.51)	7 (16%)	0.86 (0.32,2.25)
Annual income						
<¥10 000	44 (24%)	1	75 (41%)	1	33 (18%)	1
¥10 001–30 000	70 (24%)	**0.52 (0.29,0.91)**	111 (39%)	0.64 (0.39,1.03)	88 (31%)	1.24 (0.71,2.17)
¥30 001–50 000	31 (29%)	**0.46 (0.22,0.93)**	29 (27%)	**0.28 (0.14,0.56)**	25 (24%)	0.62 (0.29,1.30)
>¥50 000	26 (26%)	0.50 (0.25,1.02)	40 (40%)	0.68 (0.36,1.29)	36 (37%)	1.44 (0.72,2.88)

(Continued)

Table 3. (Continued).

	Anxiety (n, %)[a]	Adjusted OR (95% CI)[b]	Depression (n, %)[a]	Adjusted OR (95% CI)[b]	PTSD (n, %)[a]	Adjusted OR (95% CI)[b]
Flood exposure						
No house damage	148 (26%)	1	218 (38%)	1	151 (27%)	1
House damage	21 (21%)	0.95 (0.50,1.81)	35 (35%)	0.87 (0.49,1.53)	30 (31%)	1.66 (0.89,3.10)
No injury	135 (24%)	**1**	236 (37%)	1	164 (26%)	**1**
With injury	15 (39%)	**4.06 (1.58,10.43)**	17 (44%)	2.19 (0.89,5.37)	17 (44%)	**8.17 (3.04,21.93)**
No relative injured or die	155 (24%)	1	239 (38%)	1	165 (26%)	**1**
Have relatives injured or die	13 (40%)	1.50 (0.63,3.57)	14 (43%)	1.38 (0.58,3.251)	16 (50%)	**2.65 (1.12,6.30)**
≤ ¥ 10 000 property loss	50 (17%)	**1**	88 (31%)	**1**	65 (23%)	1
¥ 10 001–30 000 property loss	70 (32%)	**2.79 (1.70,4.57)**	93 (43%)	**1.67 (1.08,2.58)**	59 (28%)	1.21 (0.74,1.96)
¥ 30 001–50 000 property loss	23 (35%)	1.76 (0.89,3.50)	23 (35%)	1.00 (0.52,1.90)	29 (45%)	1.73 (0.89,3.38)
> ¥ 50 000 property loss	22 (35%)	**2.42 (1.21,4.82)**	36 (58%)	**2.66 (1.41,5.02)**	24 (38%)	1.74 (0.87,3.48)
Mental Health Counselling						
No received	151 (25%)	1	228 (38%)	1	168 (28%) (28%)	1
Received	20 (29%)	1.46 (0.82,2.59)	27 (39%)	1.18 (0.68,2.04)	14 (20%)	0.62 (0.33,1.18)
Total	**171 (25%)**		**255 (38%)**		**182 (27%)**	

[a] Missing values are excluded. [b] ORs and 95% CI. Values are adjusted for all variables in table.
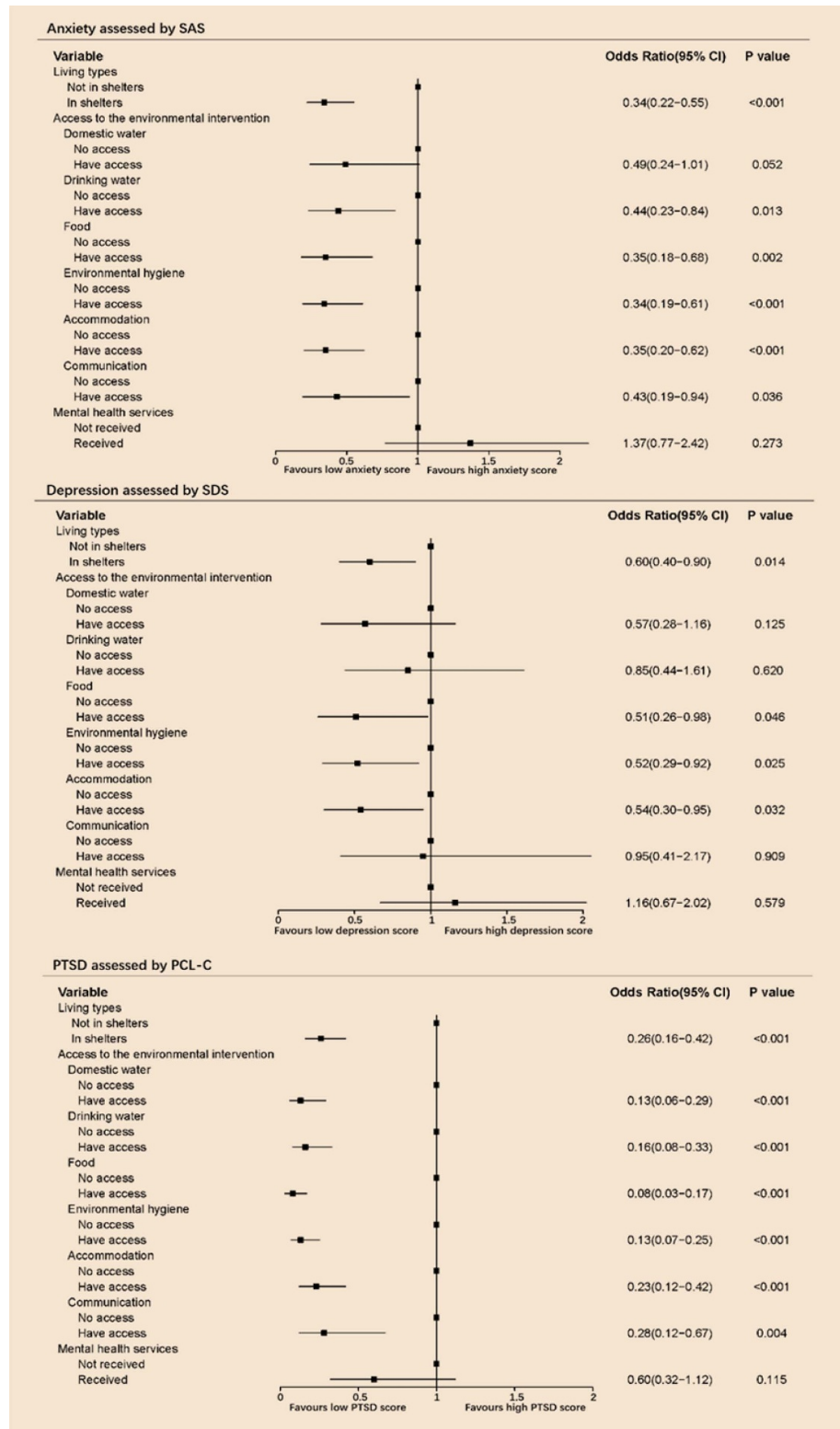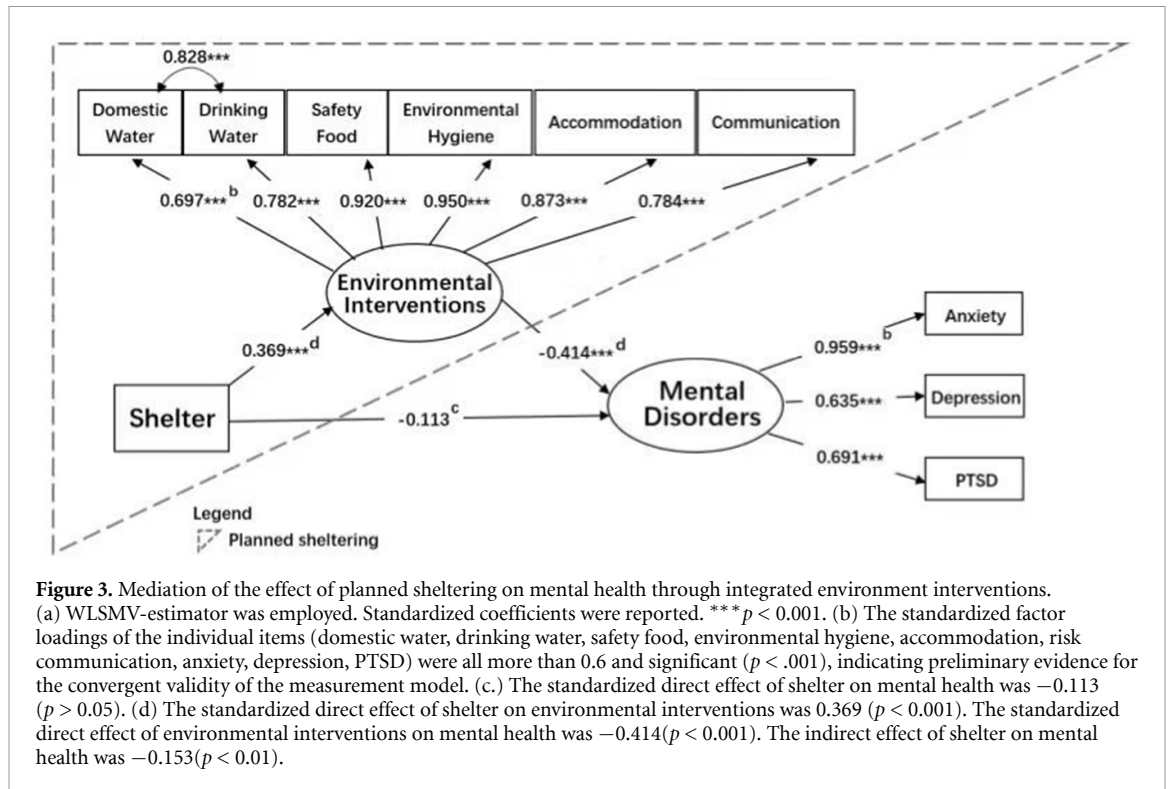
10

Figure 2. Adjusted ORs of anxiety, depression, and PTSD by flood victims' reported to have access to various environmental interventions. ORs are adjusted for sex, age, profession, education, marital status, annual income, injury, house damage and family economic loss. P values are ORs for people who reported to have access to various environmental interventions.

housing design that could integrate all characteristics above and could additionally enhance the housing stability with sufficient living conditions and environmental hygiene for the victims to maintain not only their physical but also psychological health (The Global CCCM Cluster 2014).

However, the serious shortage of psychological professional medical staff in China leads to the

Figure 3. Mediation of the effect of planned sheltering on mental health through integrated environment interventions. (a) WLSMV-estimator was employed. Standardized coefficients were reported. ∗∗∗$p < 0.001$. (b) The standardized factor loadings of the individual items (domestic water, drinking water, safety food, environmental hygiene, accommodation, risk communication, anxiety, depression, PTSD) were all more than 0.6 and significant ($p < .001$), indicating preliminary evidence for the convergent validity of the measurement model. (c.) The standardized direct effect of shelter on mental health was -0.113 ($p > 0.05$). (d) The standardized direct effect of shelter on environmental interventions was 0.369 ($p < 0.001$). The standardized direct effect of environmental interventions on mental health was -0.414($p < 0.001$). The indirect effect of shelter on mental health was -0.153($p < 0.01$).

insufficient psychological interventions and consultations to the victims after disasters, and these psychological interventions were mainly targeted to the direct injuries or victims with major losses or mental problems during disasters, rather than covering all the victims (Wu *et al* 2019). This may result the low percentage of mental health counselling of both the intervention group (15.4%) and the control group (15.6%), and thus these psychological interventions' effect on mental health was difficult to identify.

Additionally, this study firstly attempted to identify flood sheltering as the primary exposure to affect mental health rather than the flooding itself and explored its potential pathways, compared with the previous flooding studies (Fussell and Lowe 2014, Warsini *et al* 2014). In previous studies, evacuation and sheltering was identified as a secondary interruption, increasing mental health problems among flood victims through modifying other secondary exposure, including further affecting stable living, breaking original social ties, deteriorating their living conditions and surrounding environment, as well as changing their daily routines (Fussell and Lowe 2014; Porter and Haslam, Porter and Haslam 2005, Reed *et al* 2011). Previous studies have highlighted the importance of reducing post-disaster housing instability and effective sheltering, which may reduce mental health vulnerability (Porter and Haslam 2005, Fussell and Lowe 2014). However all of these studies did not identify sheltering as the primary exposure to examine the effectiveness of its policy interventions on mental health and identify the potential pathways.

Although a large number of studies found that the displacement and adverse post-disaster social and environmental conditions had a significant and long lasting effect on mental health (Alderman *et al* 2012, Hu *et al* 2015, Dai *et al* 2016a). However, to date, few research has found causal evidence regarding any protective effect of these environmental interventions on mental health of IDPs, only some studies have examined the potential linkages of better mental health outcomes with good living conditions using regression models.(Porter and Haslam 2005, Reed *et al* 2011, Munro *et al* 2017). This may because mental health of flood victims is an important issue but was usually neglected by many governments especially when more attention was concerned on fatalities and physical health (Zhong *et al* 2018).

For the exploration of potential influencing mechanisms and a framework for future policy planning, we compared the IHMF with the existing global research. We found that several interventions may be effective to protect mental health. The first is an implementation of basic environmental safety standards in disaster shelters (The Global CCCM Cluster 2014; The UN Regugee Agency 2014; The, 2015). Adequate provisions, such as supplying safe water, sufficient food and environmental hygiene, made IDPs less anxious and prevented diseases, and thereby may improve physical health. Living with better physical health can also enhance wellbeing as well as willingness of social support to mitigate a flooding event's typical negative mental health impacts (Norris *et al* 2002, Xu *et al* 2013, Dai *et al* 2016b). The effect

of organizational and community factors in modifying the impact of disasters on mental health reflects the Flood Impact Framework developed by Longman et al, (Longman *et al* 2019) which stressed the importance of a systems approach to preparing and responding to climate change related extreme events. We considered planned shelters as special communities appropriate to implement a policy experiment, as these environmental interventions were implemented more intensively in planned shelters than general flooding areas attributed to a greater concentration of victims, personnel, government agencies and dispatches (The Global CCCM Cluster 2014, Wu *et al* 2019). These strategies conducted in the planned shelters imply a more in-depth investigation of organizational and community protective factors, which may maintain perceived community resilience among victims, even if they are faced with socioeconomic loss including serious damage to their original home.

The second protective measure in the planned shelters is to provide stable accommodation with original living arrangements maintained, permitting flexible living period and having good risk communication. In Anhui, the communities at risk were displaced as a whole to flood shelters, which were established with pre-designated facilities. The school-cum-shelter is regarded as the best option to reduce housing instability and mitigate exposure to environmental hazards (The Global CCCM Cluster 2014). Additionally, maintaining the community pre-flood arrangement and government management in stable accommodation could strengthen original social ties among the victims, so as to reduce their risk of adverse mental health effects during the process of adaptation to the new environment (Dai *et al* 2016a, 2016b, Mcguire *et al* 2018), as IDPs could have more familiarity with their shelter neighborhoods and could more easily rely on support from their community (Uscherpines 2009, Wu *et al* 2019). As a result, our study has not identified social ties as a mediating effect between planned sheltering and mental health, as in this study scenario, these social ties within the displaced group (intervention group) and within the control group have not significantly different. The local government also applied good risk communication including mobile text messaging, local media and home visits to release useful information and conduct health education of how to prevent infectious diseases among the victims, which was helpful to relief their mental stress and panic. Finally, the majority of shelters existed for long stays of at least two months, which reduced the number of times of displacement, and only after all the victims finally returned home were the shelters closed. In this case, the duration of the mass sheltering may play a vital role in mitigating the negative mental health effects compared to those short-term sheltering or community for several times.

It is a global challenge for governments to respond to the negative mental health impacts of flooding or other extreme weather events' displacement effectively. Mass evacuation and sheltering are commonly used strategies not only for disaster risk reduction but also for climate change adaptation, and thus are aligned with the 2030 Sustainable Development Goals (SDGs) of conducting climate actions, maintaining good health and reducing disaster risk by offering a short-term resettlement with a sustainable and resilient community (The Global CCCM Cluster 2014, Wu *et al* 2019). Thus, we suggest that the planned sheltering is not only a special community to reduce the short-term impacts from an extreme weather event, but must also with long-term social and environmental sustainability for disaster victims to stay frequently especially in climate-sensitive regions. The planned shelter could even maintain socio-psychological comfort if it could maintain good living conditions, environmental hygiene, social ties and even strengthen community cohesion through organization management and community planning (Nigg *et al* 2006). Our study therefore provides a better understanding of the relationship between displacement, policy intervention, environmental conditions and mental health, which can be used to enhance the planning protocols of government sectors, stakeholders and local community to facilitate disaster recovery after an extreme event.

Several limitations should be acknowledged. First, the mental health problems were evaluated based on self-assessment questionnaire, which are not as accurate as the clinical diagnoses. Thus, we suppose that the questionnaire reflects potential psychological problems rather than clinically diagnosed diseases, and thus our estimated rates may be slightly higher than the clinical rates. Secondly, displaced people are difficult to follow up, thus this research is a cross-sectional study to examine the relationship between planned sheltering and mental health, but in the future more longitudinal studies are needed to elucidate complex causal pathways. Thirdly, psychological counselling services in China mainly target people at high-risks of post-disaster mental illnesses, and this causal negative relationship between psychological counselling and mental illness, adding the low utilization rates that all restrict our ability to further evaluation of its impact on mental health. Additionally, as the response rate of young victims was low as they were busy which may underestimate the mental health problems especially among the intervention group with less percentage of young people. Also, the selection bias might still be exist when comparing the intervention- and control- groups, and found that the displaced group had more percentage of vulnerable populations (e.g. victims who suffered injuries and losses) than the non-displaced group but had better mental health outcomes. Thus, this selection bias may underestimate the protection effect of planned shelters on mental health. Finally, as there was no obvious distinguish of social support (e.g. the relatives and

friends support, local government support) between the IDPs and the control group, and even there was more social support for vulnerable populations and the populations with loss in the flooding, this may cause we have not found social support was an effective pathway of planned sheltering to reduce mental disorders in the SEM.

5. Conclusions

This research is one of the early attempt to discuss whether the planned temporary resettlement with integrated policy interventions is effective in protecting mental health of IDPs. Our results provided an evidence base that environmental interventions of providing clean water, safe food, environmental hygiene, risk communication and sufficient accommodation had a protective effect on reducing the risk of psychological problems. How used the planned sheltering to achieve better mental health outcomes in China would inform other flood-prone areas to mitigate psychological vulnerability of the IDPs.

Acknowledgments

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

Conflict of interests:

The authors declare no competing interests.

Author contributions:

SZ and CH designed the study and drafted the paper. SZ, ZW and MP collected data and performed the analysis, with input from CH HCH, SC, and EJ contributed to revising and finalizing the paper.

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