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The Influence of the Deteriorations in Living Environments on the Health of Disaster Victims Following a Natural Disaster

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Abstract

Relief housings are used to quickly provide disaster victims with a temporary living place whenever there is a natural disaster. However, few previous studies on the influences of the deterioration in living environments on the health of the disaster victims in relief housings might be identified. Therefore, a study on the influence of the deteriorations in living environments on the health of disaster victims following a severe natural disaster has been carried out and the study results are reported in this paper. Field tests on the thermal environment inside relief housings and questionnaire survey on the health of disaster victims in relief housings in Wenchuan earthquake disaster settlement area were performed. The study found that the thermal environment in relief housings was very poor in summer days, and that the deteriorations in the living environment had significantly negative impacts on the disaster victims' mental state, sleep duration, appetite, and body weight. It also found that frequency of sickness, especially cold and heatstroke increased after moving into the relief housings. In addition, the number of doctor visitings by disaster victims in tents and in prefabricated houses increased by 55.4% and 44.4%, respectively. The study results revealed that it is of great urgency to improve the living environments in relief housings following a natural disaster for the better health of disaster victims.

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1. Introduction

"5.12" Wenchuan earthquake in Sichuan, China in 2008 caused 5.36 million houses to collapse and 21.43 million to damage. As a result, more than 13 million disaster victims were relocated [1]. In order to meet the housing requirements for the victims as soon as possible, relief housings including temporary tents and prefabricated houses were quickly built up. This provided the disaster victims with transitional residences before finding their permanent housings [2]. Because of the severe damage caused by the earthquake, finding the permanent housings through quick reconstruction was hardly possible. Disaster victims had to live in relief housings for as long as up to two years before the completion of reconstruction [3]. However, the impacts of the deteriorations in living environments on disaster victims' health are often ignored, as the focus following a natural disaster has been usually to get the victims settled with temporary housings as soon as possible, without looking at anything beyond this focus. More than 10 million disaster victims in Wenchuan earthquake disaster settlement area had to live in these temporary relief housings. Therefore, first-hand data and study samples can be obtained and collected to understand the living environment in the relief housings following a natural disaster and its impacts on the health of disaster victims.

Temporary relief housings constructed using light-weighted materials have poor thermal performance and are vulnerable to extreme weather. Previous studies [4, 5] have suggested that thermal environment inside temporary housings may be much worse than that outside, with higher indoor air temperature in hot days and lower indoor air temperature in cold days than that in ordinary residential buildings. Therefore, although relief housings can be used to provide disaster victims with a temporary living place on short term basis, it is very important to study the thermal environment inside relief housings, because it may seriously impact disaster victims' mental and physical health. Consequently, how to maintain a suitable indoor environment is very important for temporary housings when used in hot seasons in hot/warm regions. Zaki et al. [6, 7] conducted experimental studies inside a tent with a canopied east-facing attic-type roof. The results showed that this simple arrangement reduced daily heat gain by 46-49% for days with clear sky. In addition, the heat transfer coefficient for a tent with an inclined fabric top was 2 to 3 times larger than that with smooth metal plate top. Hu [8] carried out a comparative study on tents with and without drenching water, and found that the use of drenching water on outside surfaces obviously improved the internal thermal environment of the tents. Yang [9] studied the thermal performance of green heat reflective coatings used for army tents. After using the coatings, the surface temperature and indoor air temperature of the tents could be effectively decreased.

Although the thermal environment inside temporary housings has gradually been studied, most of the reported studies were mainly on how to improve the thermal environment inside temporary housings. Few studies have focused on the impact of the deteriorations in living environment on the health of disaster victims following a natural disaster [10, 11]. Therefore, the objective of the study reported in this paper is to investigate the influence of the deteriorations in living environment on the mental and physical health of the victims living in relief housings after Wenchuan earthquake.

2. Methods

Both the field test and questionnaire survey methods were adopted. The thermal environment in relief housings in Wenchuan earthquake disaster area were firstly studied. This was followed by administrating a questionnaire survey to find out the level of influence of the deteriorations in living environment on disaster victims' health.

2.1. Field test

During initial site visits, it was found that the indoor thermal environment inside relief tents and prefabricated houses was far away from satisfaction. Most disaster victims living there complained that the thermal environments inside these tents/prefabricated houses were unbearable, significantly affecting their health. Thus, a tent in the resettlement area in Mianzhu City was chosen as a study tent. The following parameters, indoor and outdoor air

temperatures, inside tent surface temperature, relative humidity, were measured at two modes: a closed mode with all the windows and doors closed, and an open mode with all the windows and doors opened. A portable temperature and humidity meter was used to measure the indoor and outdoor air dry bulb temperature and relative humidity (± 0.8 °C for temperature and $\pm 3\%$ R.H. for humidity). The tent surface (roof and wall) temperatures were measured using a non-contact infrared thermometer with a response time of 500 ms, and a measuring range of -32 °C to $+380$ °C, at accuracy of ± 2 °C. All the measuring instruments were pre-calibrated.

2.2. Questionnaire survey

The disaster area covered a total of 100,000 km². Four cities within the disaster areas, Dujiangyan, Beichuan, Jiangyou and Mianzhu City where questionnaire survey was carried out were chosen, as these cities were seriously hit by the earthquake, and the number of disaster victims were very large. Furthermore, given the total number of victims, both tents and prefabricated houses were used to house disaster victims of different background such as urban residents, business owners, students and the surrounding villagers, etc.

Table 1. Content of questionnaire about the health of disaster victims

<p>1. You are Male/Female, age.</p> <p>2. Where do you live after the earthquake?(tick only one) a). tent b). prefabricated house c). temporary building d). sleep outside e). former housing</p> <p>3. Number of people living there ; Area m².</p> <p>4. Are there followings: (multi tick is allowed) a). fan b). refrigerator c). air conditioner d). none</p> <p>5. How long do you stay indoor during daytime on sunny days? (tick only one) a). 0-2 hours b). 2-4 hours c). 4-6 hours d). 6-8 hours e). >8 hours</p> <p>6. How long do you stay indoor during daytime on windy or rainy days? (tick only one) a). 0-2 hours b). 2-4 hours c). 4-6 hours d). 6-8 hours e). >8 hours</p> <p>7. Do you notice the followings indoor: (multi tick is allowed) a). stuffy b). muggy c). moist d). many mosquitos e). others (please specific)</p> <p>8. Due to the change in living environment, your mental state is: (tick only one) a). bad b). poor c). fair d). good e). others</p> <p>9. Due to the change in living environment, your sleeping duration is: (tick only one) a). decreased b). unchanged c). increased</p> <p>10. Due to the change in living environment, your appetite is: (tick only one) a). improved b). unchanged c). deteriorated</p> <p>11. Due to the change in living environment, your weight are than before: (tick only one) a). decreased b). unchanged c). increased</p> <p>12. Due to the change in living environment, the frequency of occurrence for the sickness listed has been increased: (multi tick is allowed) a). cold b). fever c). heatstroke d). diarrhea e). dyspepsia</p> <p>13. Due to the change in living environment, the number of your doctor visitings is: (tick only one) a). decreased b). unchanged c). increased</p> <p>14. Due to the change in living environment, which of the following you cannot be tolerant of most? (limited to two choices) a). lack of health facilities b). lack of entertainment c). lack of normal diet d). poor sleep quality e). mosquitos beet f). muggy weather g). crowded</p> <p>15. What can you do to improve quality of the living environment in relief housings? (please provide details)</p>

In order to ensure the best possible true reflection of the relationship between the deterioration in living environments and disaster victims' health, the questionnaire used in the survey was designed according to the actual situation specific to earthquake disaster areas. Table 1 shows the contents of the survey form. It was designed to be

concise and clear in order to allow the victims in disaster areas to respond easily. There were totally 15 questions, and the questions in this survey form were finalized following a test run of survey.

The questionnaire survey was conducted from 24 July to 5 August, 2008. Given that disaster victims' health might be influenced by either the deterioration in living environments or the direct consequence of earthquake such as the loss of their loved ones, to properly account for the influence on victims' health due only to the deteriorations in living environments, only these victims without the loss of loved ones were invited to join the survey. Further, the chosen ones did not have the history of mental disorder and sleep disorder.

350 questionnaire survey forms were randomly distributed in the above mentioned three cities and one county. 316 were returned with a response rate of 90.3%. After removing invalid returns, there were totally 300 valid returns. 73 were collected in the Qingjianrenjia settlement area, and 50 in Wenxinjiayuan settlement area, both of Dujiangyan City, 46 in Beichuan settlement area, 54 in Jingpengjingtai settlement area of Jiangyou City and 77 in Mianzhu City settlement area. Due to the difficulties of conducting the survey in the disaster area with casualties, the sample size were considered adequate to draw meaningful conclusions.

For the 300 respondents, the male to female ratio was 88.68:100, which was different from that of the 2010 national population census data for Sichuan Province of 103.14:100 [12]. This was because some male victims participated in post-disaster reconstruction and stayed in temporary housings for fewer hours than female victims during day time, leading to a lower male gender ratio than the census data for Sichuan Province. The age ranges of respondents were between 9 and 87, with an average age of 40. Furthermore, 40% of the returns were collected from victims living in tents and 60% in prefabricated houses, respectively.

3. Results and discussion

In this section, the results of both the field tests on the indoor thermal environment inside a tested tent and questionnaire survey are separately reported.

3.1. Field test results

Fig. 1 shows the measured indoor air temperatures inside the tested tent in both close and open modes, and the measured outdoor air temperature in a sunny afternoon from 12:00 am to 4:00 pm. It can be seen that the measured air temperature inside the tent in close mode was much higher than the outdoor air temperature, with a maximum difference of 15°C. At the open mode when door curtain was rolled up and all the windows were opened, the measured indoor air temperature was still 7°C higher than that of outdoor air. Therefore, as compared to close mode, up to 9°C indoor air temperature reduction can be resulted in at open mode. Nonetheless, even at open mode, it appeared that it was still too hot to stay inside.

Fig. 2 shows the comparisons between the measured inside roof surface temperatures of the tested tent and outdoor air temperature. It can be seen that inside roof surface temperature of the tested tent at close mode was 23.9°C higher than outdoor air temperature. The indoor roof surface temperature at opened mode was still as much as 21°C higher than outside air temperature. Furthermore, the measured inside wall surface temperatures of the tested tent and the outdoor air temperature are shown in Fig. 3. As seen, the inside wall surface temperature of the tent at close mode was 17.1°C higher than outside air temperature. However, at open mode, the inside wall surface temperature was still higher than outdoor air temperature, with a difference up to 13.4°C. Therefore, by comparing Fig. 1 and Figs. 2-3, it can be seen that at open mode, the reduction in indoor air temperature was more significant than that in inside surface temperatures (wall and roof). A higher inside surface temperature would influence disaster victims' thermal comfort.

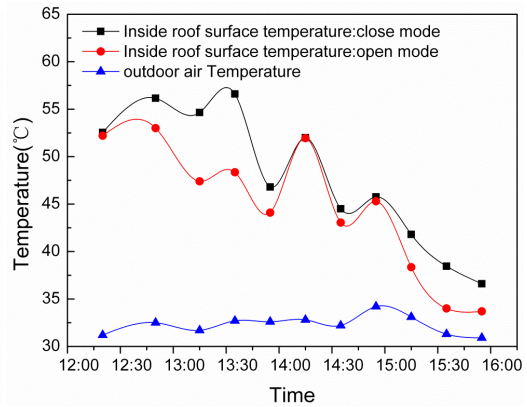
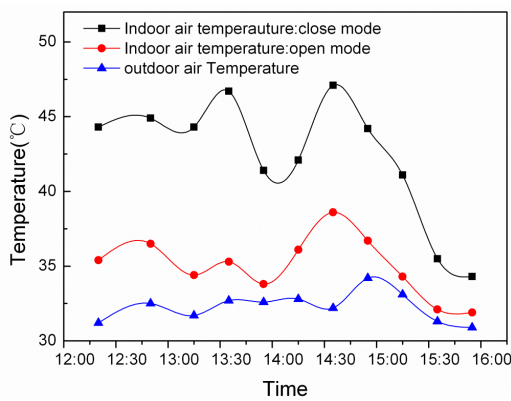


Fig. 1. The measured air temperatures inside the tested tent at both open and close modes, and the measured outdoor air temperature (the left one)

Fig. 2. The measured inside roof surface temperature of the tested tent at both open and close modes, and the measured outdoor air temperature (the right one)

Fig. 4 shows the data of measured indoor air temperature and relative humidity in the tested tent plotted on a psychrometric chart. The CIBSE design Guide specifies discomfort temperature thresholds for overheating in non-air conditioned buildings of 28°C (except for bedrooms where a lower threshold of 26°C is specified) [13]. It can be seen from Fig.8 that the measured indoor thermal environment inside the tested tent was significantly poorer than the thresholds suggested by CIBSE at both open and close modes. This explained why the disaster victims strongly complained about the thermal environment inside temporary relief housing being intolerable.

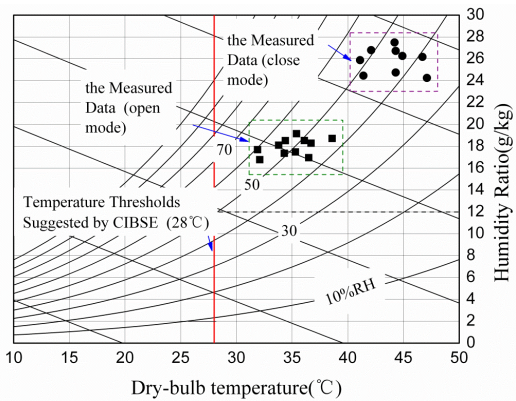
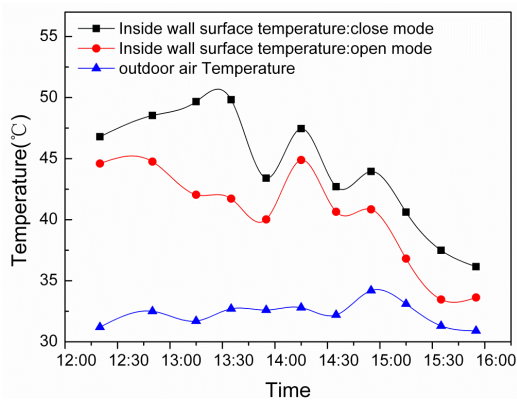


Fig. 3. The measured inside wall surface temperature of the tested tent at both open and close modes, and the measured outdoor air temperature (the left one)

Fig. 4. The measured data from the tested tent plotted on a psychrometric chart (the right one)

The field test results shown in Figs 1-4 reveal that the thermal environment inside relief housings was far from satisfactory in hot summer days. Hence, a follow-up study on the influence of the deteriorations in living environment on disaster victims' health was initiated and carried out by questionnaire survey. The survey results are shown in the next section.

3.2. Results of questionnaire survey

By analysing the 300 number of returned survey forms, the following can be observed.

Fig. 5 shows the surveyed results of mental state for disaster victims after moving into relief housings. It can be seen that, when living in relief tents, the mental state of 43.8% of the victims surveyed was bad, 39% poor. On the other hand, when living in prefabricated houses, the mental state of 34.4% of the surveyed victims was bad, and 52.4% poor. Therefore, totally over 80% of the victims surveyed were at abnormal mental state. It can be also noticed that the mental state of the victims living in tents tended to be worse.

Fig. 6 shows the survey results of the change in sleep duration for disaster victims after moving into relief housings. It can be seen that when living in tents, 64.2% of disaster victims surveyed experienced decreased sleep duration and that when living in prefabricated houses, 50% of the surveyed victims experienced decreased sleep duration. With the deteriorations in living environments, sleep duration for most disaster victims was reduced. With reduced sleep durations for most victims living in temporary relief housings, their mental state can also be affected.

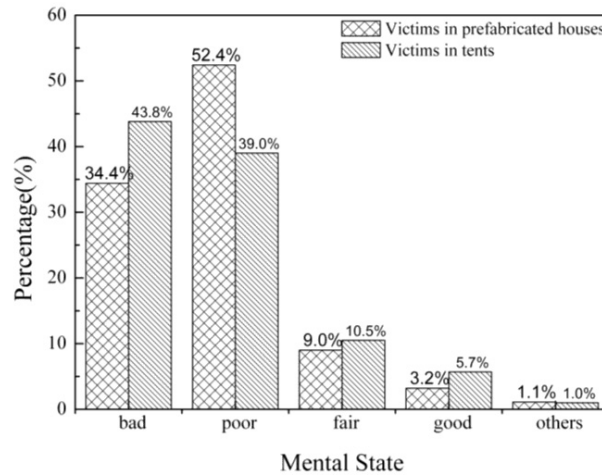


Fig. 5. The surveyed mental state of disaster victims after moving into relief housings (the left one)

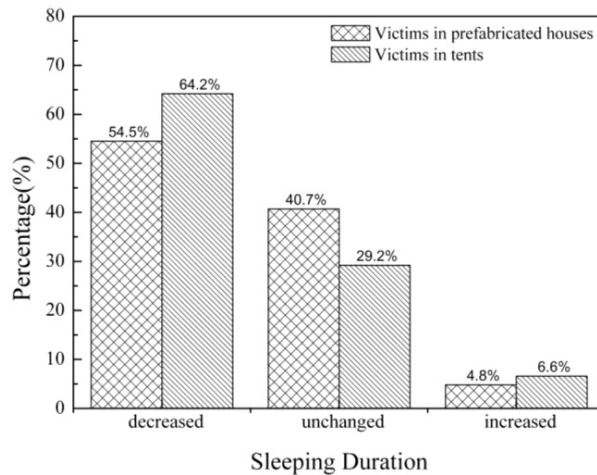


Fig. 6. The changes in sleeping duration for disaster victims after moving into relief housings (the right one)

Figs. 7 and 8 show the changes in appetite and weight for disaster victims after moving into relief housings. 64.2% of surveyed disaster victims living in tents and 54.5% in prefabricated houses had reduced appetite. On the other hand, 68.9% and 58.6% of surveyed victims living in tents and in prefabricated houses, respectively, lost weight. One of the reasons contributing to the weight loss was poor thermal environment inside relief housings. Because the indoor air temperature and inside surface temperature of relief housings were very high, so that heat dissipated of a human body cannot be transmitted into surroundings by convection or radiation, but by sweating, leading to the loss of appetite. As appetite was lost, the weight loss was a naturally consequence.

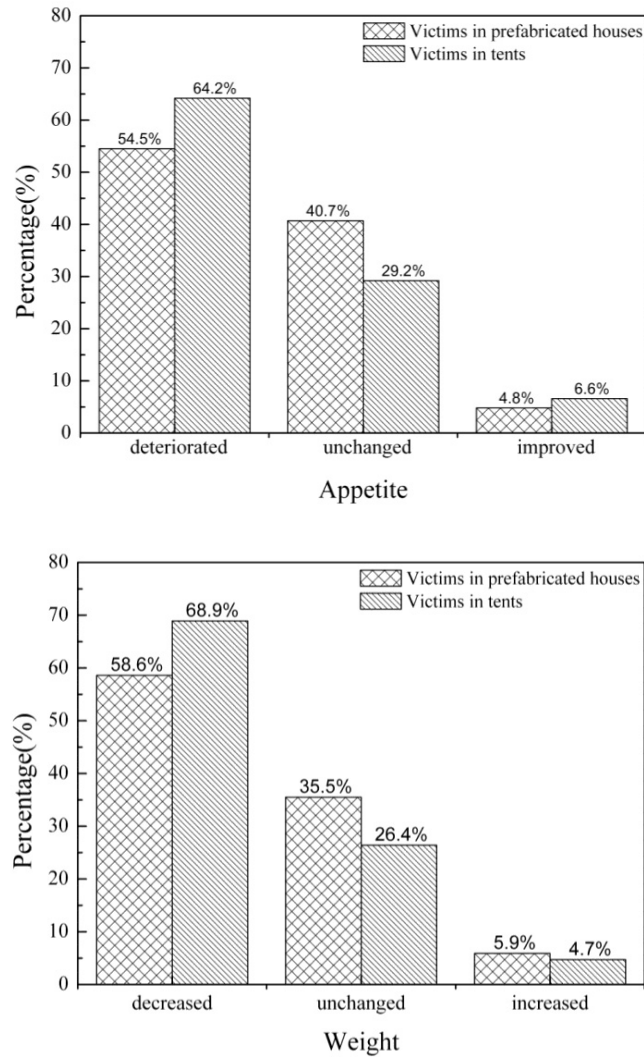


Fig. 7.& Fig. 8. The changes in appetite and weight for disaster victims after moving into relief housings

Fig. 9 shows the survey results of the votes by the disaster victims after moving into the relief housing on increasing frequency of sickness occurrence. 48.1% of disaster victims living in tents thought that the frequency for their catching cold after moving into tents was increased. This was followed by 39.6% on heatstroke, 32.1% on dyspepsia and 19.8% on diarrhea, respectively. On the other hand, 39.6% of surveyed victims living in prefabricated houses voted that the frequency for their catching cold was increased. This was followed by 37% on heatstroke, 25.5% on dyspepsia, and

21.9% on diarrhea.

Fig. 10 shows the changes in the number of doctor visitings after moving into relief housings. It can be seen that 55.4% of disaster victims living in tent and 44.4% in prefabricated houses increased the number of doctor visitings. However, for 50.8% living in tents and 37.6% in prefabricated houses, the number of doctor visitings remained unchanged.

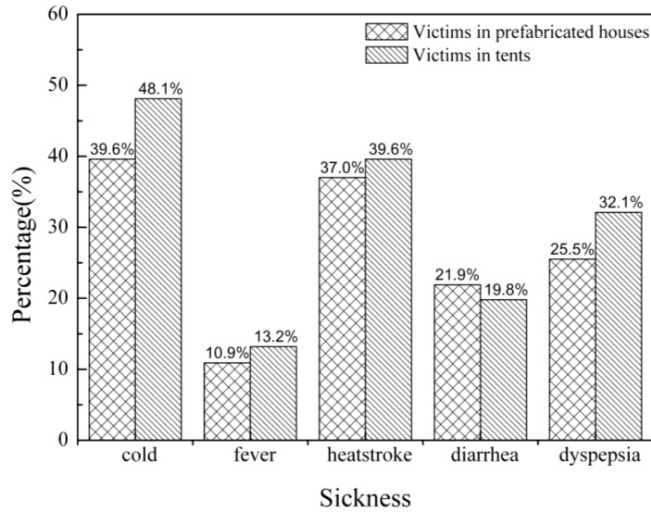


Fig. 9. Votes by the disaster victims after moving into relief housings

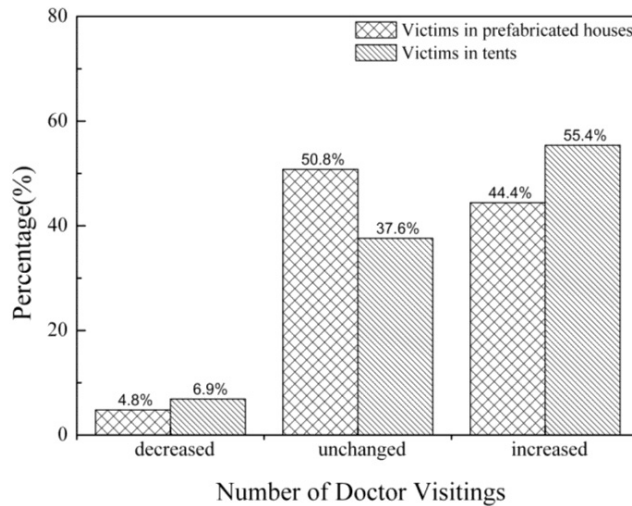


Fig. 10. The changes in number of doctor visitings for disaster victims on increasing frequency of sickness occurrence victims after moving into relief housings

4. Conclusions

Field tests were used to quantitatively study the thermal environment inside relief housings and the health of disaster victims after moving into relief housings were studied using questionnaire survey. The conclusions are drawn as follows: 1) Thermal environment in relief housings (tents and prefabricated houses) was very poor at both close

mode and open mode in summer days; 2) Indoor air temperature dropped obviously at open mode, however, the inside surface temperatures (wall and roof) were only slightly decreased, and were still much higher than outdoor air temperature; 3) The deterioration in living environment clearly had negative effects on the physical and mental health for disaster victims. The disaster victims' mental state, sleep duration, appetite, and body weight were all changed with varying degrees after moving into the relief housing. In sum, in order to uphold the health of the disaster victims, it is recommended to improve the living environment in relief housings.

Acknowledgements

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