



Research article

Elements that associate with participants' psychological discomfort during simplified fire drills

Zhao Longlong^{a,b}^a Renmin University of China, School of Philosophy, Beijing, China^b University College London, Department of Political Science, London, UK

ARTICLE INFO

Keywords:

Participants' psychological discomfort
Simplified fire drills
Postgraduate students
The awareness of precaution
Procedural arrangement

ABSTRACT

Fire drills may reinforce the survival skills of participants on the one hand, and on the other hand, they might bring a certain amount of psychological discomfort. To identify elements associated with the psychological discomfort, a designed questionnaire was distributed to postgraduate students who had experienced fire drills in Islington (London) and 1640 valid responses were obtained. With the help of regression analysis, this research found that participants' awareness of precaution, individual initiative of participation, the personal judgement of simplified fire drills (SFDs), participation of SFDs, evaluation of SFDs' function in practical applications, and satisfaction with SFDs' performance are positively associated with participants' psychological discomfort, while the procedural arrangement of SFDs, time interval of joining in the last SFD, and the frequency of simplified fire drills experienced are negatively associated with participants' psychological discomfort. Moreover, personal awareness of precaution, individual initiative of participation, individual satisfaction with SFDs' performance, the time interval of joining in the last SFD, procedural arrangement of SFDs, and the frequency of simplified fire drills experienced could explain 30.02% of the variance in participants' psychological discomfort.

1. Introduction

Evacuation drills may improve participants' survival skills to a certain extent, and at the same time, it is also likely to bring participants some psychological discomfort, such as panic, depression, and distress [1,2]. Mild psychological discomfort that arose in evacuation drills has a limited negative impact on the participants, and it can be alleviated mainly by catharsis, confession, and self-regulation [3,4]. In contrast, moderate or severe psychological discomfort presented in evacuation drills has an evident negative influence on the participants mentally and physically, and relevant drugs or clinical psychologists are often needed during the process of treatment [5,6].

In addition, the degree of participants' psychological discomfort in evacuation drills might deepen with an increase in the frequency of evacuation drills, especially when there are many flaws in the procedural arrangement; the more times it is repeated, the easier it is for the participants lead to be disturbed by moderate or serve psychological discomfort [7,8]. Thus, in the scenario of fire drills, a group of scholars advocate that the possibility of being disturbed by psychological discomfort may be reduced by perfecting the procedural arrangement of fire drills [9,10].

To achieve this goal, researchers have conducted many discussions on how to better a simplified fire drill (SFD), but there is a lack of corresponding attention to other factors associated with participants' psychological status, such as individual initiative of

E-mail address: longlong.zhao.19@ucl.ac.uk.

<https://doi.org/10.1016/j.heliyon.2023.e16635>

Received 17 February 2023; Received in revised form 15 May 2023; Accepted 23 May 2023

Available online 26 May 2023

2405-8440/© 2023 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

participation and awareness of precaution [11,12]. Therefore, this paper compares the six possible elements that may be associated with participants' psychological discomfort, namely X2, X3, X4, X5, X6, and X7 (for specifics on what these variables correspond to, please see Table 1 and Fig. 1), and examines their differentiating associations with participants' psychological discomfort (Y) in simplified fire drills.

In contrast to an unabridged fire drill, the simplified fire drill (SFD) primarily refers to a simple evacuation activity related to fires without the participation of firefighters and burning flames [13]. A ringing alarm, some participants who are not in a hurry to escape, and one or more safety inspectors are the three main elements of SFD, especially in the UK [14].

After implementing a survey, the authors found that students' accommodation operated by the authority of universities or colleges in London had hosted SFDs more than once in the past month. From the data collected, 46% of respondents clarified that psychological discomfort would disturb them after hearing the fire alarm in their department. Therefore, to prevent participants from being disturbed by the mental discomfort as much as possible, it is crucial to explore how to reduce the possibility of its occurrence in fire drills (especially SFDs) from the perspective of associated factors.

With the help of regression analysis, this paper analyzes nine factors that may be associated with participants' psychological discomfort (for specifics on what these variables correspond to, please see Table 1). According to the results presented, three conclusions could be drawn. To begin with, individual evaluation of SFDs' function in practical applications, individual participation of SFDs, the individual judgement of SFDs, individual satisfaction with SFDs' performance, individual awareness of precaution and individual initiative of participation are positively associated with participants' psychological discomfort, while time interval of joining in the last SFD, procedural arrangement of SFDs, and the frequency of simplified fire drills have a negative association with participants' psychological discomfort. Furthermore, individual satisfaction with SFDs' performance, individual awareness of precaution, individual initiative of participation, the time interval of joining in the last SFD, the frequency of simplified fire drills experienced, and procedural arrangement of SFDs could explain 30.09% of the variance in participants' psychological discomfort. Finally, of the six factors associated with participants' psychological discomfort, the individual initiative of participation was the most influential, followed by individual satisfaction with SFDs' performance and procedural arrangement of SFDs.

2. Main hypotheses

Compared with the literature on fire disasters, the research on fire drills is quite deficient [15]. Most researchers tend to explore how to extract the experience of preventing fire disasters via the virtual practice or training created by advanced technologies, only a few of scholars focus on the psychological discomfort during fire drills [16]. A group of researchers argued that a keen awareness of precaution could assist tertiary students in dealing with problems aroused by various disasters, and they recommended cultivating participants' sense of precaution [9]. Besides, Adhiutama et al. proved that the awareness of precautions could alter the behavioural responses of participants in 2020. Meanwhile, they found that there was an association between individual participation and participants' psychological state during a drill [17]. And a similar association between participants' engagement and their awareness of disaster preparedness was found by Ozkazanc and Yuksel in 2015. In addition, Pancani et al. held that the level of participation motivated by official force associated with participants' mental health negatively in 2021. Thus, it is reasonable to make the following predications [18].

Hypothesis 1. Individual awareness of precaution on SFDs significantly associates with their psychological discomfort. (H1)

Hypothesis 2. Individual participation of SFDs significantly associates with their psychological discomfort. (H2)

Vorst (2010) deemed that there was a connection between evacuation arrangements and the psychological parameters of participants. Afterwards, Adhiutama et al. pointed out that an improved evacuation procedure may weaken the negative impact of a disaster in 2020. Additionally, Sheek-Hussein et al. proposed that improving managerial procedures might limit the negative psychological impacts of disasters in 2021. Consequently, it is safe to predict that procedural arrangements may associate with the psychological discomfort.

Table 1
Variables and their corresponding meanings.

Variables	Corresponding Meaning	Notes
X1	Individual initiative of participation	X1 is measured by Question 20
X2	The frequency of simplified fire drills experienced	X2 is measured by Question 6
X3	Individual evaluation of SFDs' function in practical applications	X3 is measured by Question 15
X4	Individual satisfaction with SFDs' performance	X4 is measured by Question 7
X5	Individual awareness of precaution on SFDs	X5 is measured by Questions 8 and 9
X6	Procedural arrangement of SFDs	X6 is measured by Questions 10, 11, 12 and 13
X7	Individual participation of SFDs	X7 is measured by Question 14
X8	Individual judgment of SFDs	X8 is measured by Question 16
X9	Time interval of joining in the last SFD	X9 is measured by Question 17
X10	Personal gender	X10 is measured by Question 2
X11	Personal age	X11 is measured by Question 3
X12	Personal nationality	X12 is measured by Question 4
Y	Perceived participants' psychological discomfort	Y is measured by Questions 18 and 19

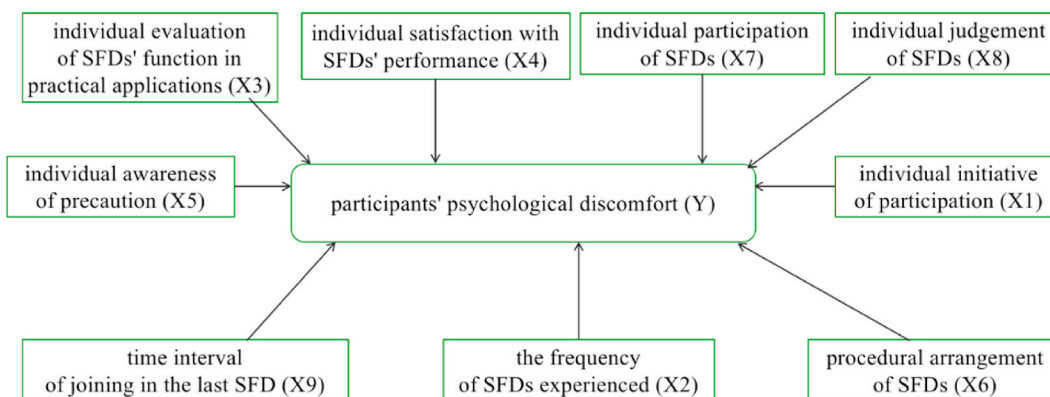


Fig. 1. Elements that associated with participants' psychological discomfort during SFDs.

Hypothesis 3. The procedural arrangement of SFDs significantly associates with participants' psychological discomfort. (H3)

Evaluation and satisfaction are two types of subjective feedback given by participants [19,20]. Collecting feedback from participants helps the organizers build up a comprehensive performance picture of the activity or drill, and it could create a chance to improve or perfect [21,22]. Meanwhile, it can also provide the participants with an opportunity to express their comments [23]. So, participants' evaluation and satisfaction should be emphasized for an activity or drill [24]. At present, there is not much literature devoted to analyzing the association between participants' evaluation/satisfaction and their psychological discomfort. Most researchers have focused their research on the following two aspects. Firstly, they would like to investigate the evaluation and satisfaction toward an activity or a drill [25]. Secondly, they prefer to discuss how to improve personal evaluation and satisfaction via mending some specific procedures of an activity or a drill [26]. In the literature on threat response or emergency management, only a few scholars have investigated the link between participants' subjective feedback and their mental health, along with the relationship between the performance of the drill and its psychological impact on the participants [27]. The personal satisfaction and evaluations surveyed in this study are the individual perceptions. More specifically, the personal satisfaction mainly refers to the extent to which the participants are satisfied with the performance of SFDs they have participated (please see question 6 in the questionnaire for details). And the personal evaluation mainly refers to the subjective perception of SFDs' function in practical (please see question 14 in the questionnaire for details). Although both personal satisfaction and evaluation are subjective perceptions of the participants, there is a big difference in what they focus on. The former focuses on measuring participant's subjective satisfaction of the results presented by a simplified fire drill, while the latter concentrates on evaluating the functions of a simplified fire drill perceived by participants. In a nutshell, there is no obvious overlap between them.

As for the association between individual satisfaction and participants' psychological discomfort, Cornell & Sheras believed that a satisfactory evacuation plan is less likely to have a negative effect on participants psychologically [28]. Then, Adamson & Peacock found that when participants rated the evacuation plan higher, they were less likely to be disturbed by the psychological discomfort [29]. What's more, Ji et al. proposed that individual satisfaction with evacuation activities significantly connected with their mental health [30]. Regarding the association between personal evaluation and mental health, Jiao thought that they had a certain correlation [31]. Thereafter, Tian proved that personal evaluation associated with participants' mental health in some specific scenarios of drills [32]. Moreover, Arnetz & Blomkvist regarded personal evaluation as a kind of performance feedback and verified that it associated with participants' psychological status in 2007. And this view was retested and affirmed by Chinaveh et al., in 2010. Based on these findings, it is rational to predict that individual satisfaction and evaluation might associate with participants' psychological discomfort.

Hypothesis 4. Individual evaluation of SFDs' function in practical applications significantly associates with their psychological discomfort. (H4)

Hypothesis 5. Individual satisfaction with SFDs' performance significantly associates with their psychological discomfort. (H5)

Finally, for the victims, the negative psychological effect of dual disasters is more potent than one [33]. As for multiple disasters, they were more likely to leave the survivors a trauma for a long time [34]. ElSherief et al. claimed that as the frequency of school shooter drills increases, the number of participants with mental health issues (such as anxiety and depression) could climb correspondingly [35]. Afterwards, Santos-Reyes in 2020 found that the frequency of earthquake mass evacuation drills could have a significant effect on participants psychologically. Therefore, the organizer should scientifically adjust the frequency of drills according to the specific situation [36]. Additionally, Nickerson & Schildkraut came to a similar conclusion as Santos-Reyes when they explored the impact of lockdown drills [37]. Hence, it is logical to infer that the frequency of SFDs experienced may associate with participants' psychological discomfort.

Hypothesis 6. The frequency of SFDs experienced significantly associates with participants' psychological discomfort. (H6)

3. Data and methodology

A series of questionnaires were sent to a batch of full-time postgraduate students who live in student accommodations managed by their colleges/universities in London. The author was a postgraduate student, and more than half of the author's friends were postgraduates. Therefore, selecting postgraduates as the primary target indicated that it was not challenging for the author to quickly collect a large amount of data. Moreover, all experimental protocols were approved by the Ethics Committee of the Renmin University (ID: 2020000950/003), and the Ethics Committee of University College London also approved them.

With the help of convenience sampling, the authors conducted an anonymous survey of four student apartments in the Islington borough of London between March 1 and April 1, 2022. The authors created an anonymous questionnaire on SurveyMonkey, an online platform that can be used to create questionnaires and collect data, consisting of two parts. The first part had four questions, which investigated respondents' education level, gender, birth year, and nationality, and all these questions were fill-in-the-blanks. According to the data collected, the author classified the answer to these questions into various points. As for the first question, "1" represented "undergraduate", and "2" represented "postgraduate". For the second question, "1" stood for "male", and "2" stood for "female". Then, "1", "2", "3", "4", and "5" in the third question represented "18–21 years old", "22–25 years old", "26–29 years old", "30–33 years old", and "34 and over 34 years old" respectively. Afterwards, "1", "2", "3", and "4" in the fourth question stood for "British", "China", "Japan", and "France" individually.

The second part had sixteen questions, and they explored nine aspects, namely X1, X2, X3, X4, X5, X6, X7, X8, and X9 (for specifics on what these variables correspond to, please see Table 1 and Fig. 1). All these questions employed a five-point scale, ranging from "1" (strongly agree) to "5" (strongly disagree). It was worth noting that the participants' psychological discomfort was a perceived variable measured by themselves, not by other rating scales in mental health, as it was much easier to collect a mass of data in a limited time.

After investigation, the authors found nearly 3500 residents in the targeted student apartments in the Islington borough of London, including about 2400 postgraduate students. Therefore, the authors decided to set the sample size of this survey in 2000. Before starting the large-scale questionnaire distribution, the authors implemented a pilot test. A week later, the authors received 251 responses. Upon examination, the authors found that the questionnaire had a good performance in terms of internal consistency (Cronbach's $\alpha = 0.763$). At the same time, the questionnaire also performed well in construct validity (KMO = 0.752, P value of Bartlett's = 0.000). In addition, according to the results of regression analysis, it can be found that the data obtained in this pre-test was suitable for testing the six hypotheses proposed. So, a large-scale data survey was launched.

The large-scale survey had two parts. Firstly, the author sought help from his friends who lived in the targeted student apartments. The author forwarded the anonymous questionnaire on SurveyMonkey to them and asked them to distribute it to their classmates. Secondly, the author bought ten iPads and imported the questionnaire into them. Subsequently, the author led his investigation team to begin the investigation at the gates of the four apartments mentioned above. After obtaining the respondent's consent, the iPad with the questionnaire was placed in the respondent's hands. It was estimated that each respondent took about 10 to 15 min to complete a questionnaire. In order to avoid the same respondent filling out the questionnaire repeatedly, a special reminder was set on the initial page of each questionnaire (if you had already filled out the questionnaire, please do not fill it out repeatedly, thanks). Each respondent who filled out the questionnaire received a coupon or souvenirs brought by the author from China.

After 30 days, the authors distributed 2000 questionnaires and recovered 1640 valid responses. After the data collection, the author examined the questionnaire's reliability coefficient (Cronbach's α) and constructed validity (KMO and Bartlett's test). According to the results of α presented, the reliability coefficient of the questionnaire is acceptable. The overall α of the questionnaire is 0.728, and the α of individual awareness of precaution, procedural arrangement, and perceived psychological discomfort were 0.739, 0.752, and 0.774, respectively. Meanwhile, the KMO and the P value of Bartlett's test were 0.711 and 0.000 individually, indicating that the questionnaire's construct validity was middling. Thus, the data collected by the questionnaire had an adequate reliability coefficient and construct validity.

In addition, in order not to bring potential troubles to the respondents, the author made appropriate exclusions of some information related to the university/college and apartment where the respondents lived when designing the questionnaire. Finally, after gathering

Table 2
Descriptive statistics for variables.

Variable	Mean	Standard deviation	Min	Max
Individual evaluation of SFDs' function in practical applications (X3)	3.196	0.980	1	5
Individual satisfaction with SFDs' performance (X4)	3.186	1.061	1	5
Individual participation of SFDs (X7)	2.745	1.106	1	5
Individual judgement of SFDs (X8)	2.562	1.154	1	5
Individual awareness of precaution on SFDs (X5)	2.734	1.029	1	5
Individual initiative of participation (X1)	2.677	1.162	1	5
Time interval of joining in the last SFD (X9)	2.839	1.087	1	5
Participants' psychological discomfort (Y)	2.633	0.995	1	5
The frequency of simplified fire drills (X2)	2.665	1.143	1	5
Procedural arrangement of SFDs (X6)	3.480	1.055	1	5
Personal age	2.884	0.638	1	4
Personal nationality	2.018	0.785	1	4
Personal gender	1.494	0.500	1	2

Note: personal age/nationality/gender is classified from 1 to 4/1 to 4/1 to 2.

all responses, the author chose Stata (a complete and integrated statistical software that provides its users with data analysis) to analyze the possible associations among the targeted variables with the help of regression analysis.

4. Findings

The author distributed 2000 questionnaires and recovered 1640 valid responses, with a recovery rate of 82%. According to the results, 830 males (50.61%) and 810 females (49.39%) participated in the survey. The age of respondents was mainly concentrated “26–29 years old” (76.22%). Moreover, 64.02% of the respondents are Chinese, followed by British (21.34%). Furthermore, the number of French and Japanese respondents was 140 (8.54%) and 100 (6.10%) individually. As the number of postgraduates covered in this survey (nearly 2000 individuals) was similar to the total graduate students in the targeted apartments (about 2400 residents), this survey can be a good representation of the postgraduates who lived in the four apartments.

Table 2 presents the general description of the main variables. Moreover, Table 3 shows the results of the bivariate correlations. Table 3 shows that individual participation, judgement, evaluation, satisfaction, and awareness of precaution had a weak positive correlation with participants’ psychological discomfort. In comparison, the correlation between the time interval of joining in the last SFD and participants’ psychological discomfort was much weaker. Afterwards, an individual initiative of participation and participants’ psychological discomfort had a medium positive correlation. At the same time, there was a medium negative correlation between the procedural arrangement of SFDs and participants’ psychological discomfort. Lastly, the frequency of simplified fire drills experienced, and participants’ psychological discomfort had a weak negative correlation.

To further clarify the above quantitative relationship, this study employed regression analysis to explore the association between X1/X2/X3/X4/X5/X6/X7/X8/X9 and Y (shown in Table 4). So, in Model 1, X3, X4, X7, X8, X5, X1, X9, X2, and X6 were treated as the independent variables, and Y was regarded as the dependent variable. Based on what was shown in Table 4, X4, X5, and X1 had a positive association with Y significantly. While X9, X2, and X6 presented a negative association with Y robustly. Additionally, the positive association between X3/X7/X8 and Y was insignificant. Thus, Model 2 and Model 3 should be established accordingly. Table 5 showed a significant positive association between X4/X5/X1 and Y, which means that H1 and H5 could pass the test and be accepted. Meanwhile, X9/X2/X6 was negatively associated with Y, which means that H3 and H6 could pass the test and be accepted. Furthermore, Table 6 presented a positive association between X3/X7/X8 and Y, indicating that H4 and H2 could pass the test and be accepted.

As for Model 2, X4, X5, X1, X9, X2 and X6 provided a 30.09% explanation for the variance of Y. In Model 3, X3, X7 and X8 presented an 8.68% explanation for the variance of Y. Compared with Model 3, Model 2 had a larger Adjust R-squared. Furthermore, it can be inferred that X1, X4, and X6 were the primary elements associated with participants’ psychological discomfort. Besides, to test whether participants’ psychological discomfort differed in terms of gender, age/nationality, T-tests and ANOVA tests were employed accordingly. From the results presented by the T-test, there was no difference in the psychological discomfort of the subjects in terms of gender (the P value was not significant). According to the results showed by the ANOVA test, there was no significant difference in participants’ psychological discomfort in age/nationality (the P value was not significant). Thus, the influence of gender/age/nationality on participants’ psychological discomfort tended to be insignificant in this study. As the respondents selected by the author were all postgraduates, it was difficult to analyze the impact of education level on participants’ psychological discomfort. Nevertheless, the impact of cultural background, beliefs, education level, nationality, age, and gender should be further investigated in the following research related to simplified fire drills.

5. Discussion

In general, fires may bring a certain degree of psychological trauma and some property damage to the victims [38]. To minimize these, SFDs or FDs were created as they could raise participants’ awareness of disaster prevention and practice their survival skills [39]. However, participants of SFDs might be bothered by some psychological discomfort. Although the psychological discomfort of SFDs was less harmful than the trauma that a fire may inflict on the victim [11]. It is likely to become a worse problem for the participants mentally if it is not addressed and handled on time [40].

The above psychological discomfort was proved to be associated with six factors related to SFDs by this study, namely individual

Table 3
Results of the bivariate correlations.

variables	Participants’ psychological discomfort
Individual evaluation of SFDs’ function in practical applications (X3)	0.230*
Individual satisfaction with SFDs’ performance (X4)	0.274*
Individual participation of SFDs (X7)	0.186*
Individual judgement of SFDs (X8)	0.198*
Individual awareness of precaution (X5)	0.251*
Individual initiative of participation (X1)	0.364*
Time interval of joining in the last SFD (X9)	0.095*
The frequency of simplified fire drills (X2)	−0.213*
Procedural arrangement of SFDs (X6)	−0.389*

Note: *indicates that the correlation coefficient passes the significance test of the 0.05 level.

Table 4
Regression results of model 1.

Participants' psychological discomfort	Coefficient	Standard Error	T value	P value
Individual evaluation of SFDs' function in practical applications (X3)	0.013	0.0232	0.55	0.581
Individual satisfaction with SFDs' performance (X4)	0.218	0.0206	10.54	0.000
Individual participation of SFDs (X7)	-0.016	0.0211	-0.76	0.448
Individual judgement of SFDs (X8)	0.020	0.0218	0.92	0.356
Individual awareness of precaution (X5)	0.092	0.0222	4.14	0.000
Individual initiative of participation (X1)	0.263	0.0202	13.03	0.000
Time interval of joining in the last SFD (X9)	-0.108	0.0217	-4.96	0.000
The frequency of simplified fire drills (X2)	-0.010	0.0195	-5.12	0.000
Procedural arrangement of SFDs (X6)	-2.211	0.0237	-8.91	0.000
Constant	2.240	0.1967	11.39	0.000

Note: Numbers of observations = 1640, Adjust R-squared = 0.3002.

Table 5
Regression results of Model 2.

Participants' psychological discomfort	Coefficient	Standard Error	T value	P value
Individual satisfaction with SFDs' performance (X4)	0.220	0.0201	10.91	0.000
Individual awareness of precaution (X5)	0.089	0.0216	4.10	0.000
Individual initiative of participation (X1)	0.268	0.0191	13.98	0.000
Time interval of joining in the last SFD (X9)	-0.103	0.0204	-5.05	0.000
The frequency of simplified fire drills (X2)	-0.104	0.0188	-5.55	0.000
Procedural arrangement of SFDs (X6)	-0.212	0.0219	-9.68	0.000
Constant	2.285	0.1652	13.83	0.000

Note: Numbers of observations = 1640, Adjust R-squared = 0.3009.

Table 6
Regression results of Model 3.

Participants' psychological discomfort	Coefficient	Standard Error	T value	P value
Individual evaluation of SFDs' function in practical applications (X3)	0.191	0.0246	7.76	0.000
Individual participation of SFDs (X7)	0.091	0.0229	3.97	0.000
Individual judgement of SFDs (X8)	0.115	0.0218	5.29	0.000
Constant	1.478	0.0953	15.51	0.000

Note: Numbers of observations = 1640, Adjust R-squared = 0.0868.

awareness of precaution on SFDs, individual participation of SFDs, the procedural arrangement of SFDs, individual evaluation of SFDs' function in practical applications, individual satisfaction with SFDs' performance, and the frequency of SFD experienced. It can be seen that this study provides a reference for how to alleviate participants' psychological discomfort during SFDs and improve the quality of SFDs.

It is evident that the frequency of drills experienced [37], individual evaluation of drills [41], individual satisfaction of drills [29], individual awareness of precaution toward drills [9], procedural arrangement of drills [16], and individual participation of drills [18, 42] have been certified to have a significant association with the psychological state of the participants in an emergency scene, except for SFD scenarios. So, this research verifies that the above elements significantly associate with participants' psychological discomfort [43]. Simultaneously, it also found that individual initiative of participation and individual judgment of SFDs were positively associated with participants' psychological discomfort, while the time interval of joining in the last SFD was negatively associated with participants' psychological discomfort.

Besides, this study still has some limitations. For example, the subjects surveyed for this study were primarily concentrated on postgraduate students. Moreover, most participants' nationalities and ages focus on China and 30–33 years old. By contrast, there were relatively few participants across other educational levels, nationalities, and age groups. Afterwards, this study paid less attention to investigating the methods of improving the quality of SFDs directly and did not conduct detailed studies on the factors related to the quality of SFDs. Then, the research subjects of this study mainly focused on four student apartments in Islington and did not investigate student accommodation in other areas of London, so the results of this study can only represent the situation of the above four student apartments, and it is hard for it to reflect the situation of all student accommodation in the city of London. Resilience and personality attributes could influence the severity of psychological discomfort. Therefore, it could be considered a study limitation.

6. Conclusions

Individual satisfaction, awareness of precaution, an individual initiative of participation, participation, the judgement of SFD, and evaluation of SFD's function in practical applications are positively associated with participants' psychological discomfort. At the same

time, the time interval of joining in the last SFD, procedural arrangement, and the frequency of simplified fire drills have a negative association with participants' psychological discomfort. Moreover, personal awareness of precaution, initiative of participation, individual satisfaction with SFDs, the time interval of joining the last SFD, procedural arrangement, and the frequency of SFDs experienced explained 30.02% of the variance in participants' psychological discomfort. Thus, according to the conclusions above, several recommendations are advocated by this research to lessen participants' psychological discomfort.

Firstly, improving participants' awareness of precaution and initiative to participate should be emphasized by the organizer of SFDs. Secondly, to promote procedural arrangements of SFDs, four aspects are needed to be perfected by the organizer of SFDs, namely pre-notification, advanced training of evacuation, evacuation procedures during the emergency and post-event experience distillation. Thirdly, excessive SFDs might bother the participants, so it is right to control the frequency of SFDs. Fourthly, it is crucial to investigate participants' evaluation of SFDs' function in practice and satisfaction with SFDs' performance at the end of a simplified fire drill. Furthermore, elevating the evaluation and satisfaction might positively impact decreasing psychological discomfort. Fifthly, the SFDs should not serve as a decoration, as the primary function of SFDs is to enhance the survival skills of targeted participants. Finally, the organizer should consider the psychological conditions of SFD participants to detect and treat potential psychological problems as early as possible.

Ethics approval and consent to participate

All methods were carried out in accordance with relevant guidelines and regulations. All experimental protocols were approved by the Ethics Committee of the Renmin University (ID: 2020000950/003), and the Ethics Committee of University College London also approved them. Written informed consent was obtained from all subjects and/or their legal guardian(s).

Availability of data and materials

Some or all data used during the study were provided by a research group leading by the author. Anyone who wants to get access to the related datasets could send an email to jarryqotter@163.com.

Author contribution statement

Longlong Zhao: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e16635>.

References

- [1] T.J. Doherty, S. Clayton, The psychological impacts of global climate change, *Am. Psychol.* 66 (4) (2011) 265.
- [2] A. Gori, E. Topino, G. Craparo, R.L. Grotto, V. Caretti, An empirical model for understanding the threat responses at the time of COVID-19, *Med. J. Clin. Psych.* 9 (1) (2021).
- [3] T. Ryan, C. Ingleton, C. Gardiner, C. Parker, M. Gott, B. Noble, Symptom burden, palliative care need and predictors of physical and psychological discomfort in two UK hospitals, *BMC Palliat. Care* 12 (1) (2013) 1–9.
- [4] V.L. Thomas, C. Saenger, D.E. Bock, Do you want to talk about it? When word of mouth alleviates the psychological discomfort of self-threat, *Psychol. Market.* 34 (9) (2017) 894–903.
- [5] S. Kim, H.Y. Yu, H.W. Lee, Motivational determinants of digital ticketing: the mediating effect of service satisfaction and the moderating effect of psychological discomfort, *Int. J. Sports Mark. Spons.* 23 (2) (2022) 326–345.
- [6] J. Pais-Ribeiro, A. Ferreira-Valente, M. Jarego, E. Sánchez-Rodríguez, J. Miró, COVID-19 pandemic in Portugal: psychosocial and health-related factors associated with psychological discomfort, *Int. J. Environ. Res. Publ. Health* 19 (6) (2022) 3494.
- [7] S. Hönel, P. Pícha, P. Brada, L. Rychtarova, Detection Of The Fire Drill Anti-Pattern: Nine Real-World Projects With Ground Truth, Issue-Tracking Data, Source Code Density, Models And Code, 2021.
- [8] V. Van Mulukom, B. Muzzulini, B.T. Rutjens, C.J. Van Lissa, M. Farias, The psychological impact of threat and lockdowns during the COVID-19 pandemic: exacerbating factors and mitigating actions, *Translat. Behav. Med.* 11 (7) (2021) 1318–1329.
- [9] S. Ozkazanc, U.D. Yuksel, Evaluation of disaster awareness and sensitivity level of higher education students, *Proced. Soci. Behav. Sci.* 197 (2015) 745–753.

- [10] S. Zhou, D. Chen, B. Huangyang, T. Zhang, X. Xiao, R. Yu, I. Johnson, Influence of psychological factors on evacuation in fire scene based on SPSS data analysis, in: *The International Conference on Cyber Security Intelligence And Analytics*, Springer, Cham, 2022, March, pp. 527–534.
- [11] T. Lundin, L. Jansson, Traumatic impact of a fire disaster on survivors—a 25-year follow-up of the 1978 hotel fire in Borås, Sweden, *Nord. J. Psychiatr.* 61 (6) (2007) 479–485.
- [12] J. Laugharne, G. Van de Watt, A. Janca, After the fire: the mental health consequences of fire disasters, *Curr. Opin. Psychiatr.* 24 (1) (2011) 72–77.
- [13] W.F.W. Ahmad, A. Sarlan, N.A. Rauf, Escape: interactive fire simulation and training for children using virtual reality, in: *International Conference of Reliable Information And Communication Technology*, Springer, Cham, 2018, June, pp. 670–679.
- [14] J.F. Crofts, D. Ellis, T.J. Draycott, C. Winter, L.P. Hunt, V.A. Akande, Change in knowledge of midwives and obstetricians following obstetric emergency training: a randomised controlled trial of local hospital, simulation centre and teamwork training, *BJOG An Int. J. Obstet. Gynaecol.* 114 (12) (2007) 1534–1541.
- [15] H.C. Vorst, Evacuation models and disaster psychology, *Procedia Eng.* 3 (2010) 15–21.
- [16] M. Sheek-Hussein, F.M. Abu-Zidan, E. Stip, Disaster management of the psychological impact of the COVID-19 pandemic, *Int. J. Emerg. Med.* 14 (1) (2021) 1–10.
- [17] A. Adhiutama, R. Darmawan, S. Nuraeni, N.F. Pambudi, N.B. Mulyono, Relevance of disaster awareness factors and evacuation experiment without emergency alarm: fire case study, *Int. J. Emerg. Serv.* 10 (2) (2020) 177–193.
- [18] L. Pancani, M. Marinucci, N. Aureli, P. Riva, Forced social isolation and mental health: a study on 1,006 Italians under COVID-19 lockdown, *Front. Psychol.* 12 (2021), 663799.
- [19] B. Arnetz, V. Blomkvist, Leadership, mental health, and organizational efficacy in health care organizations, *Psychother. Psychosom.* 76 (4) (2007) 242–248.
- [20] M. Chinaveh, N.M. Ishak, A.M. Salleh, Improving mental health and academic performance through multiple stress management intervention: implication for diverse learners, *Proced. Soci. Behav. Sci.* 7 (2010) 311–316.
- [21] Zhiqin Sang, Fu Gan, The relationship between family environment, professional satisfaction and the mental health of freshmen, *Psych. Behav. Res.* (2) (2015) 278–282.
- [22] Mengqi Li, Nanke Li, Rui Gao, Zuoshan Li, Social support and mental health of the disabled: the mediating role of life satisfaction, *Psychol. Res.* (2) (2016) 54–60.
- [23] Xiaoyan Yuan, Qiang Yu, Research on Life Satisfaction, Mental Health Status and Their Relationship Among High School Physical and Art Students, 05, *Journal of Panzhihua University*, 2013, pp. 34–37.
- [24] F. Luthans, J.B. Avey, B.J. Avolio, S.J. Peterson, The development and resulting performance impact of positive psychological capital, *Hum. Resour. Dev. Q.* 21 (1) (2010) 41–67.
- [25] Mengran Chen, Group psychoanalysis and government response in public crisis: a case study of salt grabbing incident, *J. Donghua Univ.* (3) (2015) 142–149.
- [26] Na Wei, Can Yang, Xiaozhen Wang, The impact of government information release on public psychology in major public crisis emergencies: data analysis based on COVID-19 epidemic, *Jiangsu Soc. Sci.* 3 (2020) 10–22+241.
- [27] Xue Lan, Qin Zhu, International references for crisis management: a case study of the U.S. Public health emergency response system, *Chines. Admin.* (8) (2003) 51–56.
- [28] D.G. Cornell, P.L. Sheras, Common errors in school crisis response: learning from our mistakes, *Psychol. Sch.* 35 (3) (1998) 297–307.
- [29] A.D. Adamson, G.G. Peacock, Crisis response in the public schools: a survey of school psychologists' experiences and perceptions, *Psychol. Sch.* 44 (8) (2007) 749–764.
- [30] Ji Xinbo, Yonghong Wang, Chunhui Zhao, Research on the Psychological Adaptability and Satisfaction of College Students and the Needs of Mental Health Education, *China Health Education*, 2019, pp. 92–95, 01.
- [31] Lan Jiao, Pay Attention to Evaluation and Improve the Effect of Mental Health Education, *China Higher Education*, 2014, pp. 56–57+63. Z2.
- [32] Xueying Tian, The relationship between emotional expression and personal evaluation of college students and social anxiety, *Chinese School Health* 11 (2007) 991–992.
- [33] T. Niitsu, K. Takaoka, S. Uemura, A. Kono, A. Saito, N. Kawakami, E. Shimizu, The psychological impact of a dual-disaster caused by earthquakes and radioactive contamination in Ichinoseki after the Great East Japan Earthquake, *BMC Res. Notes* 7 (1) (2014) 1–7.
- [34] L.M. Gargano, J. Li, L. Millien, H. Alper, R.M. Brackbill, Exposure to multiple disasters: the long-term effect of hurricane sandy (october 29, 2012) on NYC survivors of the september 11, 2001, world trade center attack, *Psychiatr. Res.* 273 (2019) 719–724.
- [35] M. ElSherief, K. Saha, P. Gupta, S. Mishra, J. Seybolt, J. Xie, M. De Choudhury, Impacts of school shooter drills on the psychological well-being of American K-12 school communities: a social media study, *Humanit. Soci. Sci. Commun.* 8 (1) (2021) 1–14.
- [36] J. Santos-Reyes, Using logistic regression to identify leading factors to prepare for an earthquake emergency during daytime and nighttime: the case of mass earthquake drills, *Sustainability* 12 (23) (2020), 10009.
- [37] A.B. Nickerson, J. Schildkraut, State anxiety prior to and after participating in lockdown drills among students in a rural high school, *Sch. Psychol. Rev.* (2021) 1–13.
- [38] E. Berger, C. Gao, J. Broder, T. Campbell, D. Maybery, M. Carroll, The impact of a mine fire and smoke event on academic outcomes for primary and secondary school students, *Psych. Trauma: Theor. Res. Prac. Policy* 15 (2) (2021) 210–218.
- [39] M. Jenner, The psychological impact of responding to agricultural emergencies, *Aust. J. Emerg. Manag.* 22 (2) (2007) 25–31.
- [40] Y. Wang, J. Li, X. Zhao, G. Feng, X.R. Luo, Using mobile phone data for emergency management: a systematic literature review, *Inf. Syst. Front* 22 (6) (2020) 1539–1559.
- [41] W. Dai, X. Wan, X. Liu, Emergency event: internet spread, psychological impacts and emergency management, *J. Comput.* 6 (8) (2011) 1748–1755.
- [42] Guowen Ye, Popular participation and crisis exercises: rethinking government crisis management, *J. Party Sch. Zheji. Provin. Comm. Commun. Party China* (4) (2008) 34–38+13.
- [43] L. Zhao, P. Su, Elements that Impact on Participants' Psychological Suffering in Simplified Fire Drills, 2022.