

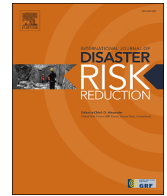


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The community resilience measurement throughout the COVID-19 pandemic and beyond -an empirical study based on data from Shanghai, Wuhan and Chengdu

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ABSTRACT

Against the backdrop of the COVID-19 pandemic, there is widespread agreement in the field of public health that community resilience should be maintained and strengthened. However, there are significant differences in the pandemic prevention effects between different communities in different areas. To explore the main influencing factors on community resilience and the magnitude of their impact during the pandemic, this study collected 650 valid questionnaires from Shanghai, Wuhan and Chengdu by using the Communities Advancing Resilience Toolkit Assessment Survey (CART). Data collection was conducted from February to March 2020 when this three cities activated a Level One public health emergency response. The data were analyzed by using multiple linear regression analysis and structural equation model. Results indicate that: (1) Domains such as Information and Communication, and Connection and Caring scored higher, while Disaster Management, Resources and Transformative Potential scored lower; (2) A community got higher resilience scores if it took more effective measures to prevent and control the pandemic (Shanghai > Chengdu > Wuhan), people within the community participated more actively in disaster risk reduction activities and activities of volunteer responder groups, and people were more closely connected with the community; (3) Variables such as the participation in affiliated volunteer responder groups, and community disaster risk reduction activities exerted the biggest impact on community resilience. Therefore, it is urgent to establish a community-based, resilience-centered framework of community resilience in the post-pandemic era. This framework will strengthen a community's capacity to cope with disasters and risks.

1. Introduction

As COVID-19 continues to rage worldwide, it has caused huge negative impacts on human life, society, economy and international political relations. The damage caused has gone far beyond the scope of public health or epidemiology, making it a global disaster with far-reaching impacts [1]. Against this backdrop, there is widespread agreement in the international community that we should maintain and strengthen community resilience throughout the COVID-19 pandemic and beyond [2,3]. Communities are the basic unit of pandemic prevention and control, so community-level countermeasures are essential for reducing virus transmission and disaster losses [4].

A community-based prevention and control strategy was firstly adopted in the early days of the COVID-19 pandemic. From January to March 2020, check points were set up at the entrances of communities, people were ordered to stay indoors and were not allowed to leave their community so as to prevent people from gathering in public spaces and keep social distancing [5]. But in reality,

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the effects of these measures differed from one community to another. Wuhan, the city most severely struck by the pandemic, took the most stringent anti-pandemic measures since the lockdown of the city in the early morning of January 23, 2020. All the citizens were ordered to stay indoors and the daily necessities were delivered to their doors. These measures prevented people from gathering around, thus cutting the spread of the disease. Similar measures were adopted afterwards in cities such as Huanggang and Xiaogan, Hubei Province as these cities were also severely hit by the coronavirus. The communities in Shanghai also took some countermeasures, including sharing information in a timely manner, strengthening people's connection and involving volunteers in epidemic prevention and control. These measures were more effective than some of the rigid measures taken somewhere else [6].

The effect of the pandemic prevention in a community depends not only on the synergy of individual efforts, but also on the unique capability a community has already possessed before a crisis happens [7]. In order to be resilient, communities should not only be fully prepared for potential crises and its outcomes, but also strengthen in advance protective factors, such as strong social networks, so as to help people and communities absorb and emerge from the crises and eventually go back to things as they were [8]. Currently, few studies probe into what specific influencing factors on community resilience are and which factors exert more impact, both in cities that are severely struck by the pandemic (like Wuhan) and those mildly affected (like Shanghai). This study collected 650 valid questionnaires from Shanghai, Wuhan and Chengdu from February to March 2020 when this three cities activated a Level One public health emergency response. The data were analyzed by using multiple linear regression analysis and structural equation model to explore the major influencing factors on community resilience and the magnitude of their impacts. The results of the analysis could then be used to propose targeted suggestions for improving the capacity of a community to cope with disasters.

2. The connotation and measurement of community resilience

2.1. Conceptual development: from disaster resilience to community resilience

The word *resilience* has a long and diverse history. The etymological roots of this word can be traced back to classical art, literature, law, and politics. In the mid-19th century, this concept found its way into the natural sciences such as mechanics and medicine. In the 1950s, the term began to migrate from the natural sciences to the social sciences. And in the 1970s, major innovations regarding this concept were achieved when it was used in ecology [9]. As the ecological environment continues to deteriorate and disasters happens more frequently, the concept of resilience has been introduced into the field of disaster management, and has become one of the most suitable paradigms for coping with uncertainties and disasters at the community level. Ever since then, this concept has received more and more attention in the academia and other professional fields [10].

As one of the first experts to probe into the resilience of social systems to disasters, Timmerman [11] integrated factors such as vulnerability and adapter capability, and defined resilience as the ability of a system (or part of a system) to adapt to and recover from hazardous events. The early disaster resilience-related studies were result-oriented and the focus was on how to emerge from the disasters and minimize disaster-incurred losses in the context of both physical and natural environment. Then, the subsequent studies on disaster resilience gradually shifted the focus to exploring the inherent capabilities of individuals and communities. Research results indicated the importance of individual and community capabilities for adapting to and coping with any crisis, and studies also revealed major intervention measures including enhancing local knowledge and strengthening existing capabilities [12,13]. Therefore, the goal of any "disaster resilience" program would be to enhance the fundamental values, assets and resources that can be applied to the process of adapting to adverse circumstances [14].

Later on, the concept of resilience was intensively applied and investigated in the field of urban planning whose focus was on disaster prevention. Community resilience, as a typical feature with practical value within a city, came under the spotlight of city resilience studies in European and American countries [15]. However, community resilience is a complicated concept as resilience is interpreted in different ways by different disciplines and community is also a vague concept. Community resilience is generally defined from three perspectives: process, outcomes and range of attributes [16,17]. (1) "Process" refers to the process of changing and adapting to disasters in affected communities [18–21]; (2) "Outcomes" refers to the desired outcome of "maintaining stable functioning" [22]; (3) "Range of attributes" takes community resilience as a set of dynamic capabilities a community possesses for maintenance, adaptation, recovery and improvement when coping with large-scale disasters or crises [23–25]. Other scholars also provided their definitions by integrating one or several of the above mentioned perspectives. For example, Ostadtaghizadeh et al. [26] defined community resilience as the ability of a system, community or society that may be exposed to hazards to effectively resist, absorb, accommodate and recover from the effects of hazards in order to achieve and maintain an acceptable level of operation. This definition has also been adopted by the United Nations International Strategy for Disaster Reduction (UNISDR).

Taken together, although there is a lack of universally accepted definition on community resilience caused by different disciplinary perspectives, the core issues and direction of research are gradually converging. Most scholars agree that community resilience is a continuous adaptation process and a dynamic set of a series of positive attributes rather than a simple static result. They also believe community resilience is the ability of a community for maintenance, adaptation, recovery and improvement when coping with large-scale disasters. In conclusion, resilience has a bright future ahead of it as an explanatory concept in various allied fields that deal with environmental extremes. However, its success in this respect will depend on not overworking it or expecting that it can provide more insight and greater modelling capacity than it is capable of furnishing [9].

2.2. The focus of measurement: from physical factors to capability factors

As the concept of community resilience has continued to evolve, there has also been increased recognition of the importance of developing methods and instruments for its assessment [27]. The promotion of community resilience relies on measures that enable (a) assessment of the factors that promote thriving and (b) assessment of resilience across locations and time [28]. Moreover, compar-

isons between different entities can be made based on the measurement results to help decision makers identify which community should be given priority to, identify specific areas for improvement, and provide the most effective interventions as required [29].

In recent years, an increasing number of different assessment models and tools for community resilience have been developed [30]. Cutter [31] analyzed systematically 27 assessment tools from four different parameters: focus, spatial orientation, methodology and domain area. It was found that none of the assessment tools took a dominant position. The most common indexes assessed were community capitals and capacities. The most widely used variable is the social capital based on religious affiliation and civic organizations. After a comparative study of 36 comprehensive and systematic assessment tools, Sharifia [32] found that most assessment tools included five dimensions: namely, environmental, social, economic, infrastructure and institutional; and community bonding and safety and well-being took a dominate role in the social dimension.

It can be seen that the community resilience assessment focuses on both tangible physical factors and intangible capability factors [33]. The physical components include infrastructure, facilities, and technology. The intangible community-related capability factors include community knowledge and learning, community connectivity and communication, community governance and leadership, community resources and capital, community disaster preparedness, community attachment and cohesion [16,34–36]. These community elements are interconnected and together form a unique community structure.

Research literature in social science shows that capability factors exert more profound impact on community resilience than tangible physical factors. Scholars have observed that the communities with more well-developed community organizations, civic associations and volunteer groups are more resilient to disasters, such as earthquakes, hurricanes, extreme weather, and the Ebola epidemic, because these communities preserve a higher level of cooperation, trust, and mutual support [20,37–39]. In particular, the studies on the COVID-19 pandemic have revealed that strong neighborhood governance, civic participation, trust in institutions, willingness to follow the government's advice and instructions can influence how COVID-19 epidemic unfolds in a neighborhood [40–42].

Therefore, when developing assessment tools, some researchers understand community resilience as a community's ability (perceived by the residents) to cope with risks. Therefore, the assessment methods they propose focus more on the evaluation of individual perception by using bottom-up and community participatory methods, which could bring many benefits to the community [32]. The most typical perception-based measurement tools include the Conjoint Community Resilience Assessment Measure (CCRAM) [43], the Analysis of the Resilience of Communities to Disasters (ARC-D) [44,45], the Community-Based Resilience Analysis (CoBRA) [46], and the Composite of Post-Event Well-Being (COPEWELL) supported by the US Centers for Disease Control and Prevention [47,48], and the Communities Advancing Resilience Toolkit (CART) [35,49].

Although the measurement of community resilience has improved greatly in the past ten years, most studies have focused on the effectiveness of assessment rather than its applicability and usability [30]. In other words, the interest in and actual practical applications of resilience thinking are ahead of the measurement. Comparative studies between different tools are rarely carried out and most studies are one-time studies [50]. Therefore, researchers and practitioners must carefully consider how to choose the appropriate measurement tools based on the actual situation.

2.3. Measurement tool selection and measurement space definition

Despite its compelling attractiveness in terms of its original coherence, simplicity, apparent completeness, adaptability and transformability, there are problems in using resilience as a universal concept [51]. In addition, as the word community has complicated connotations with vaguely defined boundaries, we must clearly state which community we will take into consideration when we conduct disaster-related action research [52].

On the one hand, the theory of resilience, migrating from ecosystem to social system, tends to depoliticize social changes [53]. In other words, there is a lack of attention in resilience theory to basic issues such as individual initiative, empowerment, political power, ideology, risk perception and diversity of cultural values [54]. On the other hand, most discussions of disaster resilience focus on or above the community level, often ignoring households at the micro level. In fact, one person's resilience may be another's vulnerability [9]. For example, indicators that are meaningful at the community level, such as the percentage of people living in poverty, the amount of community resources, etc., may be relatively ineffective in measuring how a household responds to disasters. The reason lies in that the proportion of poor people cannot be used to answer questions such as who is poor and what causes poverty. Similarly, even a community is rich in resources, we have no idea whether households or individuals can have equal and timely access to these resources. For example, during the COVID-19 outbreak, the poor and disadvantaged populations were more vulnerable to the pandemic due to reasons such as poor housing conditions and unstable income. At the same time, difficulties in obtaining timely medical services put them at greater risk [55]. Therefore, overemphasis on the resilience at the systematic level may be detrimental to the interests of the poor [56].

Therefore, it is important to take elements including political power and vulnerability as important indexes for community resilience measurement. The Community Advancing Resilience Toolkit (hereinafter referred to as CART) [35] takes these elements into consideration. For example, different from the top-down recapitulative items such as “the proportion of poor people in a community” and “the amount of resources in a community”, CART uses bottom-up approaches to get information related to a community. Perception-based items such as “people in my community are able to get the services they need” and “my community supports programs for children and families” can be used to measure the actual ability of a community to supply and distribute resources. Another important element to measure in response to the COVID-19 pandemic is the effective operation of political power. In this regard, items such as “people in my community communicate with leaders who can help improve the community”, “my community has effective leaders”, and “people in my community trust public officials” can be used to reflect the true intentions of the operation of political power. This overall consideration of relevant elements is a vital reason for using CART in this research.

In addition, an effective measurement tool should be one that has already been verified through wide applications. Among all the existing foreign assessment tools, CART is based on well-developed theories and widely used [35,57–59]. The applicability and feasibility of CART in China has been already verified [60–62]. It should be noted especially that the initial CART contained 21 items under 4 domains: Connection and Caring; Resources; Transformative Potential; and Disaster Management [49]. But given the importance of information and communication on disaster management and community resilience, a new domain-Information and Communication-was later added, increasing the total number of items from 21 to 24 [35]. In the early days of COVID-19 outbreak, the virus spread very fast and people were ordered to stay indoors, which accentuated the role of information and communication for the prevention and control of the pandemic. Therefore, the CART revised in 2015 is used in this study as the measurement tool.

In areas of work related to disaster risk, the term community and its adjunct community-based have become the default terminology in areas of work related to disaster risk. But big challenges still exist in actual work because community is a vague concept and communities differ from one to another [52]. In other words, it is biased to either use such terms without considering the context or criticize or oppose strongly their use [63]. Therefore, when we discuss community resilience, we should take into consideration the unique features of a community against the context.

In the early days of the COVID-19 outbreak, governments at different levels took standardized prevention measures including closed-loop management and home quarantine. In this situation, community, a once vague concept, became clearer. The virus spread so quickly and the whole community would be put at risk if one member was infected. This severe situation brought together individual and collective interest, where an individual better abided by community norms and became aware that he was responsible for the whole community. As a result, community became an action framework where “people united with a common purpose” [63]. In this process, people in a community can find more common grounds in terms of their beliefs, attitudes, feelings, experience, behaviors, and daily life while focusing less on their differences (or this is the case at least during the Level One public health emergency response). In addition, the neighborhood (villagers’) committees were the basic unit implementing the home quarantine order, which was a top-down management approach by the governments. Inspection sites were set up at the entrances of communities (villages) and people were restricted from going out. These measures created a relatively static situation without face-to-face social interaction and personnel flow, thus making the geographic boundaries of communities clearer.

Taking into consideration the specific administrative division in China, this study takes neighborhood committees as the basic unit for community resilience measurement. Against the backdrop of the COVID-19 pandemic, the adoption of a top-down management approach made the connotations and boundaries of communities clearer. The communities surveyed are also representative of how the cities (Shanghai, Wuhan, and Chengdu) responded to the COVID-19 pandemic.

3. Research design

3.1. Data sources

This study aims at analyzing the major influencing factors on community resilience during the initial stage of the pandemic. Therefore getting the data needed in a timely manner matters a lot to both this study and practical work. However, from February to March 2020, Shanghai, Wuhan and Chengdu activated a Level One public health emergency response, which restricted people from going outdoors. Under such circumstances, it was impossible to collect data by random sampling. Therefore, due to the constraints of time and space, we took the non-random sampling method, which was the only feasible option during the early stage of the outbreak. 650 valid questionnaires were collected through *Wenjuanxing*, an online platform for questionnaire survey, from the cities of Shanghai, Chengdu and Wuhan during February and March 2020. The survey began with locally registered community residents (who were referred to as “seeds”) from the three cities. The “seeds” then passed the questionnaire to their acquaintances. To increase the coverage and the heterogeneity of the respondents, the seeds were asked to send the online questionnaire to both male and female from different age groups. They need to ensure that the respondents had been living in a community for more than one year at the time of the survey and only one adult member from one household was enrolled in this study.

The basic demographic information of these 650 respondents is shown in Table 1 below. 41.1% of the respondents are from Wuhan, 18.3% from Chengdu and 40.6% from Shanghai. Among them, the proportion of female respondents is higher than that of male. The overall educational level of the respondents is on the high side, with about 72% holding a college or even higher degree. The respondents living in their communities for more than 5 years takes up 67%. Good educational background and at least one year of residence ensures more accurate understanding of the items in the CART Assessment Survey and more genuine and objective answers.

To address the limitations of the non-random sampling, 13 respondents were selected for in-depth interviews (12 of them are the “seeds” respondents). (1) 4 of the interviewees were officially registered in Shanghai as permanent residents. 1 out of the 4 lived in Shanghai but went back to Wuhan for the Traditional Chinese New Year every year. He went back to Wuhan with his mother on January 22, 2021 and was not able to return to Shanghai until the end of March after the lockdown was lifted. The other 3 all stayed in Shanghai throughout the pandemic. (2) 6 of the respondents were Wuhan natives who were pursuing their master's degree for the first year in Shanghai. The pandemic broke out during their stay in Wuhan for the winter vocation and they were not able to return to Shanghai until May 2020 after the lockdown was lifted. (3) 3 of the respondents were from Chengdu, who had been working and living in Chengdu throughout and beyond the outbreak. The 3 respondents from Chengdu were interviewed online through WeChat and all the other 10 were interviewed face-to-face after May 2020.

Although the severity of the pandemic and the prevention measures taken were different among the three cities during the survey period, the impact of the pandemic on the communities within each city and the top-down and uniform community-based administrative measures were similar among all the communities within one city. This dual similarity provided a relatively standardized exter-

Table 1
Demographic information of respondents.

Sociodemographic variables	Frequency	Percentage (%)
City of Location		
Wuhan	267	41.1
Chengdu	119	18.3
Shanghai	264	40.6
Age (years)		
≤30	267	41.1
31–50	290	44.6
> 50	91	14.0
Gender		
Male	220	33.8
Female	430	66.2
Marital status		
Married	380	58.5
Unmarried or others	270	41.5
Education		
Junior high school or below	50	7.7
High school	134	20.6
College or above	466	71.7
Years of residence in a community		
≤5	214	32.9
6–10	140	21.5
> 10	296	45.5

nal environment for this study. The respondents could provide more authentic and objective perception evaluation, and the differences among communities within one city could be mitigated.

3.2. Measurement of the variables

3.2.1. Outcome variable: community resilience

In this study, the final scores and the five domains of CART were used as predicated variables. The five domains include: Connection and Caring, Resources, Transformative Potential, Disaster Management and Information and Communication. The five domains consist of 24 core items, each with a number of statements on a scale from 1 to 5 (1 = strongly disagree, 5 = strongly agree).

In this study, Cronbach's alpha was used to test the internal consistency of the scale. The overall Cronbach's alpha of the scale used in this study is 0.985 with 0.927 for Connection and Caring, 0.942 for Resources, 0.961 for Transformative Potential, 0.959 for Disaster Management, and 0.945 for Information and Communication. The Cronbach's alpha for both the whole scale and each of the five domains are greater than 0.9, indicating good internal consistency.

In order to more directly show how the respondents agreed or disagreed with the statements under the items, percentage of agreement with a survey item required a response of *agree* or *strongly agree*; responses of *strongly disagree*, *disagree*, and *neither disagree nor agree* were considered not in agreement with the item statement.

3.2.2. Explanatory variables

In this study, the variables involved in disaster risk reduction activities (including whether emergency materials are prepared or not, whether you participate actively in disaster risk reduction activities, whether you receive disaster education and whether you participate in disaster prevention exercises), and variables related to the communication and interaction with the community (including whether you experience disasters, ways of communication and interaction with the community, sources of rescue in emergency situations, and participation in community volunteer activities) were taken as explanatory variables, with related social demographic variables, including gender, age, educational, marital status, years of residence in a community being controlled.

(1) Participation in Community Disaster Risk Reduction Activities

More than half of the respondents (58.8%) had emergency supplies prepared at home in case of disasters. About 56.3% had volunteered for community-based DRR activities. The proportion of respondents who had received disaster education, and participated in evacuation drills are high, accounting for 72.5% and 68.8% respectively (See [Table 2](#) for details).

(2) The Communication and Interaction between the Respondents and the Community

[Table 3](#) shows that about 18% of the respondents never had any communication with the community, and nearly 82% kept in touch with the community through different channels including work, neighbors, friends or schools. 22.5% of the respondents had experienced disasters. Only 3.4% of the respondents had no one to turn to for help in an emergency. In terms of civic engagement, only 54 had participated in volunteer activities on regular basis, accounting for 8.3%.

Table 2
Participation in community disaster risk reduction activities.

Variables for participation in DRR activities	Frequency	Percentage (%)
Having emergency supplies		
Yes	382	58.8
No	268	41.2
Being a volunteer		
Yes	366	56.3
No	284	43.7
Attended disaster education		
Yes	471	72.5
No	179	27.5
Having participated in evacuation drills		
Yes	447	68.8
No	203	31.2

Table 3
Communication and interaction between respondents and the community.

Variables for communication and interaction with the community	Frequency	Percentage (%)
Ways to communicate with the community		
No communication	118	18.2
Through work	233	35.8
Through neighbors	404	62.2
Through friends	114	17.5
Through schools	73	11.2
Has personally experienced a disaster		
Yes	146	22.5
No	504	77.5
Sources that can provide relief (support) in case of emergency		
None	22	3.4
Family members	557	85.7
Neighbors	375	57.7
Friends	399	61.4
Local organizations and institutions	353	54.3
Colleagues	242	37.2
Participation in affiliated volunteer responder groups		
Don't know	130	20.0
Know some, but don't participate in any	253	38.9
Know some, and have participated in some	213	32.8
Be a regular volunteer or a permanent member	54	8.3

3.3. Data analysis

Quantitative analysis was carried out in the first step to explore the impact of the explanatory variables on the outcome variables. CART was firstly used to descriptively analyze the overall community resilience score. Secondly, multiple linear regression model was performed to explore the influencing factors of community resilience. Finally, the mediating effect analysis of structural equation model was performed to explore the overall effect, direct effect and indirect effect (participation in community disaster risk reduction activities and community communication and interaction were taken as mediating factors affecting the overall score) of social demographic characteristics on the overall score of CART, so as to compare the impact of various influencing factors on community resilience.

It should be noted that Bootstrap method was used in this study for 1000 times of repeated sampling of the sample during multiple linear regression analysis and the development of structural equation model. In this way, the inferential statistics based on the model were made more convincing and persuasive.

In the second step, qualitative interview data was used to support the above quantitative analysis, so as to further verify the authenticity and objectivity of the research conclusions, and to further clarify and quantitative analysis results.

4. Results

4.1. Descriptive analysis of the overall score of community resilience

As shown in Table 4 below, the overall community resilience score is 3.84. Among the five domains, Information and Communication scores the highest at 3.93, followed by Connection and Caring at 3.91. Disaster Management scores 3.83, ranking in the middle of the five domains. Resources and Transformative Potential rank among the bottom at 3.75 and 3.76 respectively.

The mean scores of the 24 core community resilience items range from 3.67 to 4.03. Among them, the highest score is associated with the survey item: "People in my community help each other" in the domain of Connection and Caring, with a percentage of agree-

Table 4
Descriptive analysis of core community resilience items by domains of CART.

Domains and Items	Mean (SD)	Percentage of Agreement (%)
Domain 1: Connection and Caring	3.91 (0.81)	
1. People in my community feel like they belong to the community.	3.77 (0.99)	60.77
2. People in my community are committed to the well-being of the community.	3.92 (0.90)	68.31
3. People in my community have hope about the future.	3.94 (0.92)	68.77
4. People in my community help each other.	<u>4.03</u> <u>(0.88)</u>	<u>72.77</u>
5. My community treats people fairly no matter what their background is.	3.88 (0.95)	66.31
Domain 2: Resources	3.75 (0.89)	
6. My community supports programs for children and families.	3.93 (0.93)	68.46
7. My community has resources it needs to take care of community problems.	3.73 (0.99)	58.15
8. My community has effective leaders.	<u>3.67</u> <u>(1.03)</u>	<u>57.54</u>
9. People in my community are able to get the services they need.	3.72 (0.98)	59.54
10. People in my community know where to go to get things done.	3.69 (1.00)	57.69
Domain 3: Transformative Potential	3.76 (0.88)	
11. My community works with organizations and agencies outside the community to get things done.	3.69 (1.02)	58.92
12. People in my community communicate with leaders who can help improve the community.	<u>3.68</u> <u>(0.99)</u>	<u>57.38</u>
13. People in my community work together to improve the community.	3.91 (0.88)	68.46
14. My community looks at its successes and failures so it can learn from the past.	3.83 (0.94)	64.92
15. My community develops skills and finds resources to solve its problems and reach its goals.	3.71 (0.98)	58.15
16. My community has priorities and sets goals for the future.	3.71 (0.98)	58.46
Domain 4: Disaster Management	3.83 (0.93)	
17. My community tries to prevent disasters.	3.85 (0.99)	64.62
18. My community actively prepares for future disasters.	3.76 (1.03)	60.31
19. My community can provide emergency services during a disaster.	3.85 (0.98)	64.15
20. My community has services and programs to help people after a disaster.	3.87 (0.96)	65.08
Domain 5: Information and Communication	3.93 (0.89)	
21. My community keeps people informed (for example, via television, radio, newspaper, Internet, phone, neighbors) about issues that are relevant to them.	3.97 (0.94)	70.46
22. If a disaster occurs, my community provides information about what to do.	3.91 (0.94)	67.54
23. I get information/communication through my community to help with my home and work life.	3.85 (1.00)	64
24. People in my community trust public officials.	3.99 (0.95)	71.54
Overall Community Resilience	3.84 (0.83)	

ment of 72.8%. The statement “People in my community trust public officials” in the domain of Information and Communication comes the second at 3.99 with a percentage of agreement of 71.5%. In addition, the survey item: “My community keeps people informed (via television, radio, newspaper, Internet, phone, neighbors) about issues that are relevant to them.” in the domain of Information and Communication gets a relatively high score at 3.97 with a percentage of agreement at 70.5%.

Among the 24 core items, the two statements with the lowest scores are both related to community leaders. Among them, “My community has effective leaders” in the domain of Resources score the lowest at 3.67 with a percentage of agreement of 57.54%. “People in my community communicate with leaders who can help improve the community” in the domain of Transformative Potential gets a score of 3.68 and a percentage of agreement of 57.38% (See Table 4 below for details).

4.2. Analysis of the influencing factors of community resilience

The overall community resilience was taken as the predicted variable, and the social demographic characteristics, participation in community disaster risk reduction activities, and communication and interaction with the community were taken as the explanatory variables. Then Bootstrap method was used to construct multiple linear regression model after 1000 repeated sampling of the survey sample. The fitness of the model is appropriate with adjusted R² value of 0.292, and the Wald statistic value is 269.73 along with 95% confidence intervals, and all explanatory variables have passed the 95% confidence intervals. After optimizing the scores of each domain, the output results of the model are basically consistent with the comprehensive scores in the influence direction and significance of explanatory variables.

Table 5 indicates the following findings. (1) A community got higher resilience scores if the epidemic was prevented and controlled more effectively (Shanghai > Chengdu > Wuhan), people within the community participated more actively in disaster prevention and mitigation activities and community public welfare activities, and people were more closely connected with the community. (2) There was a significant negative relationship between educational level and community resilience score. The higher the educational level of the respondents, the lower their evaluation score of community resilience. In addition, male respondents gave significantly lower evaluation scores on community resilience than their female counterparts. (3) Compared with the respondents who had not experienced any disasters, those who had experienced disasters gave significantly lower evaluation scores of community resilience during the COVID-19 pandemic.

Table 5
Linear regression results for community resilience.

Explanatory Variables	Overall	Connection and Caring	Resources	Transformative Potential	Disaster Management	Information and Communication
City						
Shanghai	0.147* (0.017)	0.102 (0.099)	0.125 (0.062)	0.121 (0.071)	0.221** (0.003)	0.167* (0.016)
Chengdu	0.054 (0.487)	-0.043 (0.590)	0.064 (0.446)	0.066 (0.429)	0.109 (0.219)	0.072 (0.390)
Gender	-0.172** (0.006)	-0.228*** (0.000)	-0.193** (0.004)	-0.133 (0.051)	-0.162* (0.025)	-0.146* (0.028)
Education						
High school degree	-0.111 (0.343)	-0.112 (0.302)	-0.105 (0.417)	-0.121 (0.324)	-0.137 (0.304)	-0.078 (0.564)
College degree or above	-0.291** (0.005)	-0.251** (0.008)	-0.298* (0.010)	-0.326** (0.003)	-0.324** (0.006)	-0.256* (0.038)
Having emergency supplies	0.248*** (0.000)	0.230*** (0.000)	0.261*** (0.000)	0.265*** (0.000)	0.254*** (0.000)	0.229** (0.001)
Having participated in disaster risk reduction activities	0.236*** (0.000)	0.216** (0.001)	0.234** (0.001)	0.240*** (0.000)	0.248*** (0.000)	0.242*** (0.000)
Having attended disaster education	0.178** (0.009)	0.142* (0.032)	0.260*** (0.000)	0.128 (0.082)	0.217** (0.007)	0.142 (0.072)
Connection with the community through work	0.164** (0.005)	0.117 (0.050)	0.183** (0.004)	0.200** (0.001)	0.149* (0.028)	0.171** (0.009)
Connection with the community through neighbors	0.258*** (0.000)	0.284*** (0.000)	0.241*** (0.000)	0.246*** (0.000)	0.238** (0.001)	0.279*** (0.000)
Connection with the community through friends	0.166* (0.027)	0.155* (0.045)	0.206* (0.013)	0.154* (0.049)	0.200* (0.018)	0.115 (0.159)
Connection with the community through schools	0.264** (0.003)	0.149 (0.132)	0.220* (0.026)	0.304** (0.002)	0.334*** (0.000)	0.315** (0.001)
Having experienced disasters	-0.267*** (0.000)	-0.259*** (0.000)	-0.277*** (0.000)	-0.280*** (0.000)	-0.280*** (0.000)	-0.239** (0.001)
Being a volunteer	0.163*** (0.000)	0.178*** (0.000)	0.158*** (0.000)	0.187*** (0.000)	0.147** (0.001)	0.145*** (0.000)
Intercept term	3.056*** (0.000)	3.182*** (0.000)	2.937*** (0.000)	2.963*** (0.000)	3.043*** (0.000)	3.155*** (0.000)
Wald chi2	269.73*** (0.000)	222.50*** (0.000)	242.95*** (0.000)	252.15*** (0.000)	233.38*** (0.000)	203.96*** (0.000)
Adj R-squared	0.292	0.256	0.262	0.262	0.237	0.217

Note:(1) *p < 0.05, **p < 0.01, ***p < 0.001.

(2) Sociodemographic variables are set as city (Wuhan = 1, Chengdu = 2, Shanghai = 3), gender (male = 1, female = 0), education (middle school and below = 1, high school = 2, college and above = 3).

4.3. Analysis of the impact of the influencing factors

In this study, AMOS 26.0 software was used in this study to construct a structural equation model to analyze the mediating effect of the influencing factors, so as to further explore how these factors impact community resilience and the magnitude of their impacts.

4.3.1. The fitness of structural equation model of community resilience

Social sociodemographic variables are taken as the explanatory variables (although some sociodemographic variables fail to pass the significance test for multiple linear regression, they may have certain impact on the predicted variables as single factors, so it is necessary to analyze their mediating effects). The multiple linear regression analysis shows that the “city” variable only causes significant difference between Shanghai and non-Shanghai areas, and the “education” variable only causes significant differences between those with and those without a college degree. Therefore, sociodemographic variables used in this study include city (Shanghai = 1, other = 0), gender (male = 1, female = 0), education (college and above = 1, others = 0), age (over 50 = 1, 50 years old and below = 0), marital status (married = 1, others = 0), community life fixed number of year (more than 5 years = 1, 5 years and below = 0).

The overall score of community resilience is taken as the predicted variable, and the participation in community (including “participation in community disaster risk reduction activities” and “communication and interaction with the community”) is taken as the mediating variables. The item “I have personally experienced a disaster” is excluded from the model because its residual is highly correlated with the residuals of predicted variables, and the model will not meet the fit criteria if it is included. The specific path setting of the constructed structural equation model is shown in Fig. 1.

In the process of fitting the structural equation model, Bootstrap method was used for 1000 repeated sampling on the survey samples to test the mediating effect. The overall fitness of each model adjusted by MI index is shown in Table 6. All fitness indexes meet the standard, and the fitness effect of the model is ideal.

4.3.2. Analysis of the impact of the influencing factors

The output results of the structural equation model shows the total effect, direct effect and indirect effect of sociodemographic variables on the overall score of community resilience in Table 7 below:

- (1) **Variables including city, gender and education exert significant direct effects on community resilience.** The sum of the direct effects of the six sociodemographic variables on the overall score of community resilience is -0.330. City, gender and education exert significant direct effects.

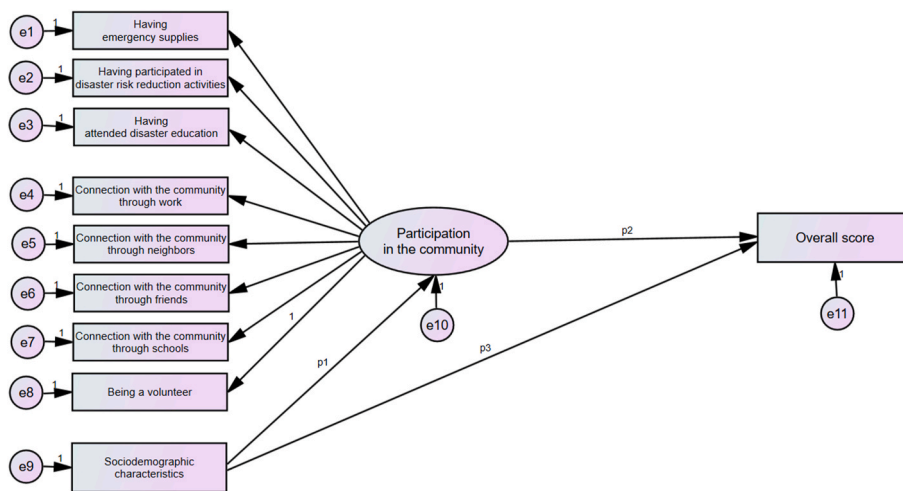


Fig. 1. Path diagram of mediating effect analysis of community resilience.

Table 6
Fitness results of community resilience structural equation model.

Fitness indexes	χ^2	RMR	RMSEA	AGFI	NFI	PNFI
Fit criteria	$p > 0.05$	< 0.05	< 0.05	> 0.9	> 0.9	> 0.5
Model1—City	26.518 (0.327)	0.007	0.013	0.981	0.959	0.511
Model2—Gender	27.774 (0.370)	0.007	0.010	0.982	0.957	0.553
Model3—Education	25.868 (0.415)	0.006	0.007	0.982	0.961	0.534
Model4—Age	27.454 (0.334)	0.007	0.012	0.982	0.958	0.532
Model5—Marital status	25.571 (0.431)	0.007	0.006	0.983	0.963	0.535
Model6—Years of residence in a community	19.245 (0.785)	0.005	0.000	0.987	0.969	0.539

Table 7
Influential effect of structural equation model of community resilience.

Model Name	Sociodemographic Characteristics->Overall Score	Sociodemographic Characteristics->Community Participation	Community participation->Overall Score	Direct Effect	Indirect Effect	Overall Effect
Model1-City	0.140* (0.027)	0.033 (0.562)	0.935*** (0.000)	0.140	0.031	0.171
Model2-Gender	-0.154* (0.017)	0.004 (0.949)	1.029*** (0.000)	-0.154	0.004	-0.150
Model3-Education	-0.167* (0.017)	-0.085 (0.157)	1.005*** (0.000)	-0.167	-0.085	-0.252
Model4-Age	-0.102 (0.261)	0.330*** (0.000)	0.928*** (0.000)	-0.102	0.306	0.204
Model5-Marital Status	-0.012 (0.855)	0.187*** (0.000)	0.932*** (0.000)	-0.012	0.174	0.162
Model6-Years of Residence in a Community	-0.005 (0.941)	0.154** (0.007)	1.005*** (0.000)	-0.005	0.155	0.150

Note:*p < 0.05,**p < 0.01,***p < 0.001.

Table 8
Nominalized path coefficient of structural equation model for community resilience.

Path relationship	Model1 City	Model2 Gender	Model3 Education	Model4 Age	Model5 Marital Status	Model6 Years of Residence in a Community
Sociodemographic Characteristics->Community Participation	0.030	0.003	-0.075	0.149	0.172	0.142
Community Participation->Overall Score	0.600	0.628	0.618	0.603	0.602	0.620
Sociodemographic Characteristics->Overall Score	0.083	-0.088	-0.091	-0.018	-0.007	-0.003
Community Participation->Connection with the community through work	0.356	0.314	0.314	0.367	0.368	0.315
Community Participation->Connection with the community through neighbors	0.284	0.260	0.264	0.276	0.280	0.284
Community Participation->Connection with the community through friends	0.300	0.308	0.280	0.292	0.290	0.300
Community Participation->Connection with the community through schools	0.180	0.186	0.183	0.201	0.205	0.179
Community Participation->Participation in volunteer responder groups	0.604	0.575	0.578	0.610	0.608	0.580
Community Participation->Preparing emergency supplies	0.449	0.455	0.454	0.450	0.449	0.457
Community Participation->Participation in disaster risk reduction activities	0.511	0.493	0.493	0.510	0.511	0.517
Community Participation->Attending disaster education	0.407	0.404	0.419	0.437	0.448	0.403

- (2) **Variables including age, marital status and years of residence in a community have significant indirect impact on community resilience through mediating effect.** The sum of the total indirect effects of the six sociodemographic variables on the overall score of community resilience is 0.585. Age, marital status and years of residence in a community exert significant indirect impact.
- (3) Sociodemographic features have a significant indirect impact on community resilience. The absolute value of the indirect effects of the sociodemographic variables on the overall score of community resilience is 0.756, higher than the direct effect of 0.580, indicating that the sociodemographic features exert more indirect than direct impact on community resilience.
- (4) **Participation in community affiliated volunteer responder groups and community disaster risk reduction activities have the greatest impact on community resilience.** The path coefficient of the nominalized latent variable of “participation-related factors” (see Table 8 below) shows that the nominalized coefficients of “participating in community affiliated volunteer responder groups”, “participating in disaster risk reduction activities”, “preparing emergency materials” and “attending disaster education” are relatively high. Therefore, participating on regular basis in affiliated volunteer responder groups and disaster risk reduction activities, preparing emergency supplies at home and attending disaster education will exert greatest impact on community resilience.

5. Conclusions and discussions

Through the multi-faceted analysis of the overall evaluation score, influencing factors and influencing effects of community resilience, this study draws the following conclusions:

5.1. The overall evaluation of community resilience is above the average

The respondents provided an above-average overall evaluation on the resilience of their communities during the pandemic.

There was effective publicity efforts on pandemic prevention. The community carried out extensive publicity through various media channels, which provided guiding information for residents. Residents had a relatively high degree of trust in government agen-

cies. The level of trust was not high at the beginning, but it increased afterwards with the improvement of the epidemic prevention and control. As one interviewee from Wuhan said:

“In fact, there is a gradual change in people's attitude towards the government. At the beginning, we were skeptical, especially when it came to the fact that the related information was not made public. But a turning point came around February 8: most of the patients were admitted into the hospital, daily necessities were supplied, and the number of confirmed and suspected cases were declining. So we felt safer, at least now we could be admitted into the hospital and we felt that we were saved. In addition, there were a lot of news reports about medical workers from other provinces and cities coming to Wuhan for support (There was a shortage of medical workers in Wuhan at that time). In this case, the advantages of our national system- the ability to mobilize all resources in a centralized way- were fully brought into play. In fact, people have strong expectations for the government and the Party.” (interviewee LJ from Wuhan)

In addition, a high degree of connection and caring was established among residents. Residents not only helped each other, but also worked together to improve the community they lived in, made their own contributions to their community, and were hopeful for their future.

The respondents provided a lower-than-average evaluation of the disaster management ability of their communities. The residents provided a relatively lower evaluation on community transformative potential, which was manifested as a lack of the ability to cooperate with external organizations, and a lack of overall planning ability. There were deficiencies in the richness and diversity of community resources, as well as residents' awareness of and accessibility to resources.

5.2. *There was a lack of strong existing social capital in the community*

In the context of community resilience, social capital refers to the engagement of community members and their willingness and ability to contribute to activities that advance the community's goals [64]. Communities with strong social capital tend to be more resilient.

There are different types of social capital, including the bonding type featuring close ties between friends and relatives, bridging type featuring the open and common participation of different groups of residents, and linking type featuring formal and institutionalized linking between members of a community and the leaders. All these different types of social capital play different but important roles contributing to community resilience [17,65]. Community cohesion, especially residents' “community awareness” and “collective action in problem solving”, is an important resource for community disaster or epidemic prevention, mitigation and preparedness [66,67]. In addition, strong and responsible leadership at the community level is one of the most important factors for dealing with the public health crisis, as strong leaders can provide correct information, manage reliable communication channels in the community, promote close communication among community residents, and these leaders establish partnerships with non-governmental organizations and promote the government and health organizations to enter the community [38].

However, the results of empirical research indicates an insufficiency of existing social capital during the COVID-19 pandemic. Although the item “People in my community help each other” scores the highest at 4.03, “People in my community feel like they belong to the community” scores low at only 3.77. The item “My community works with organizations and agencies outside the community to get things done.” scores 3.69, ranking the third from the bottom among the 24 items. The score of “People in my community communicate with leaders who can help improve the community.” is 3.68, the second from the bottom. The item “My community has effective leaders.” ranks at the bottom at only 3.67. Only 8.3% of the respondents said that they participated on regular basis in volunteer activities or were permanent members of volunteer responder groups.

In conclusion, although relatives, friends and neighbors helped each other fairly well during the COVID-19 pandemic, there was a lack of sense of identity of community residents and synergy among different groups for solving common problems. In addition, the connection between community residents and community leaders and the cooperation between communities and organizations and agencies outside the community were weak, especially the evaluation of community leaders' work efficiency was the lowest.

The respondents provided lower evaluation on the above mentioned dimensions based on the existing capacity of their communities before the pandemic on the one hand, and the actual situations during the pandemic on the other hand:

“The impact of the epidemic was too great at the beginning. We were faced with large numbers of patients, but were running short of medical supplies, daily necessities, and manpower. On top of that, we had no previous experience dealing with such huge pandemic outbreak. Primary-level workers themselves risk being infected when transporting infected patients from the community to the hospital. In this situation, I don't think the community workers can be in every way very attentive.” (Interviewee LS from Wuhan)

5.3. *Participation in community-based volunteer responder groups and disaster risk reduction activities exert the greatest impact on community resilience*

This study proves that compared with static sociodemographic factors, participation in community-based volunteer responder groups and disaster risk reduction activities exert more significant impact on community resilience, which is consistent with previous studies [35,61].

The interview data also proved the importance of participation in disaster prevention and mitigation activities:

“What impressed me the most during the epidemic is that I now understand that we must participate in the disaster relief efforts as much as we can no matter whether we are directly confronted with the disaster or not. Participation is the only way out from any disaster. Only when you participate in the disaster relief process, you will understand what hard work the workers from the neighborhood committee community are faced with. Active participation is key for the mobilization of resources. If everyone simply hides away for fear of

being infected, all the difficulties will still remain ... This sense of active participation has little to do with a person's educational background, but is more related to his sense of social responsibility. Couriers may not be highly educated, but they participated in relief efforts actively during the pandemic. Some of them helped people take care of their pets; some delivered meals to the hospital; and some ran errands for the residents ... So we still need to promote this sense of social responsibility and active participation especially in the face of disasters." (Interviewee LJ from Wuhan)

The respondents did not provide highly positive evaluation on disaster management and disaster prevention and preparedness, which is manifested as follows. (1) The respondents' evaluation on the community's disaster management, including pre-disaster preparation, emergency services during a disaster, lessons learned after a disaster, and future disaster prevention fall within the medium range. (2) Under the domain of Transformative Potential, items "My community looks at its successes and failures so it can learn from the past." and "My community has priorities and sets goals for the future." scored relatively low at 3.83 and 3.71 with a percentage of agreement of 65% and 58% respectively.

The huge gap between theory and reality, between what should be done and what is actually done further highlights that as the core intervention factor for improving community resilience, the effectiveness of community disaster risk reduction needs to be strengthened urgently. In addition, the above-mentioned elements of community action need to be combined with the sociodemographic features of the people in a community (such as different levels of education, different ages, etc.) and the features of community governance in different cities, so as to adopt different intervention strategies to better improve community resilience.

6. Implications

The Community-based Disaster Risk Management (CBDRM) emphasizes the integration of both "bottom-up" and "top-down" management, and the active participation of residents. It focuses on vulnerable groups, disaster reduction and preparedness, and incorporates disaster management into the community governance process [68]. Therefore, this study proposes that it is urgent to establish a "community-based, and resilience-centered" integrated framework for improving community resilience in the post-pandemic era (see Fig. 2 below for details). This framework mainly includes the following six parts.

6.1. "Community-based and resilience-centered" as the guiding principle

Being community-based means that in addition to taking communities as the basic unit for quarantine and epidemic prevention and control, more emphasis should be given to the following aspects: skills, knowledge, social abilities and sense of social responsibilities residents are equipped with for pandemic prevention and control; the unity and community cohesion among friends, neighbors and generations in the community; the synergy by community residents, different groups and organizations and community leaders for fighting the pandemic; and all kinds of supplies and services inside and outside the community that can be used to meet the diverse needs of community residents, especially vulnerable groups in a timely manner.

Being resilience-centered means that pandemic prevention and control should be both result-oriented, with strict top-down measures to achieve and maintain the expected outcomes; and process-oriented, with a special focus on the bottom-up active participation of community residents. With the interactive principle of providing services for the community, getting services in the community and carrying out services together with the community, residents should be able to learn and improve themselves through the process of participation [69]. In addition, being resilience-centered also means being prevention-oriented. In consideration of the current pandemic prevention and control efforts, lessons should be learnt to improve and strengthen the ability of a community to cope with risks and set development goals for future risk prevention.

6.2. Strengthening the leadership at grass-roots organizations in a community is the starting mechanism and primary intervention goal for activating community resilience

Organizations embedded in a community usually play the role of community agents. Therefore, community resilience activation occurs when agents initiate existing stocks of capital in the face of unexpected events [10]. Therefore, the degree to which community resilience can be activated depends on the amount of existing community capital on the one hand, and the ability of community agents (organizations) on the other hand [70].

In China, the organizations most deeply embedded in the community are those at the grass-roots level represented by the neighborhood committee. During the COVID-19 pandemic, the grass-roots organizations mainly adopted a top-down approach in preventing and coping with the pandemic, in the form of executing orders from authorities at a higher level, therefore they depended highly on government departments at a higher level [71]. Few communities took the initiative to respond quickly, and there were deficiencies in their response mechanisms, anti-pandemic abilities and pandemic prevention reserve [72]. The empirical results of this study also proves that residents have relatively low evaluation on the effectiveness of the work done by the leaders of the neighborhood committee.

Therefore, in the post-pandemic era, "community-level leadership capacity building" should be taken as an important starting mechanism and primary intervention goal for activating community resilience. Cadres in the neighborhood committees, community leaders and community volunteers should play a leading role. And different measures should be taken to improve the community leaders' ability to integrate resources, communicate and interact with community residents, cooperate with other community organizations, and convene and promote community collective actions.

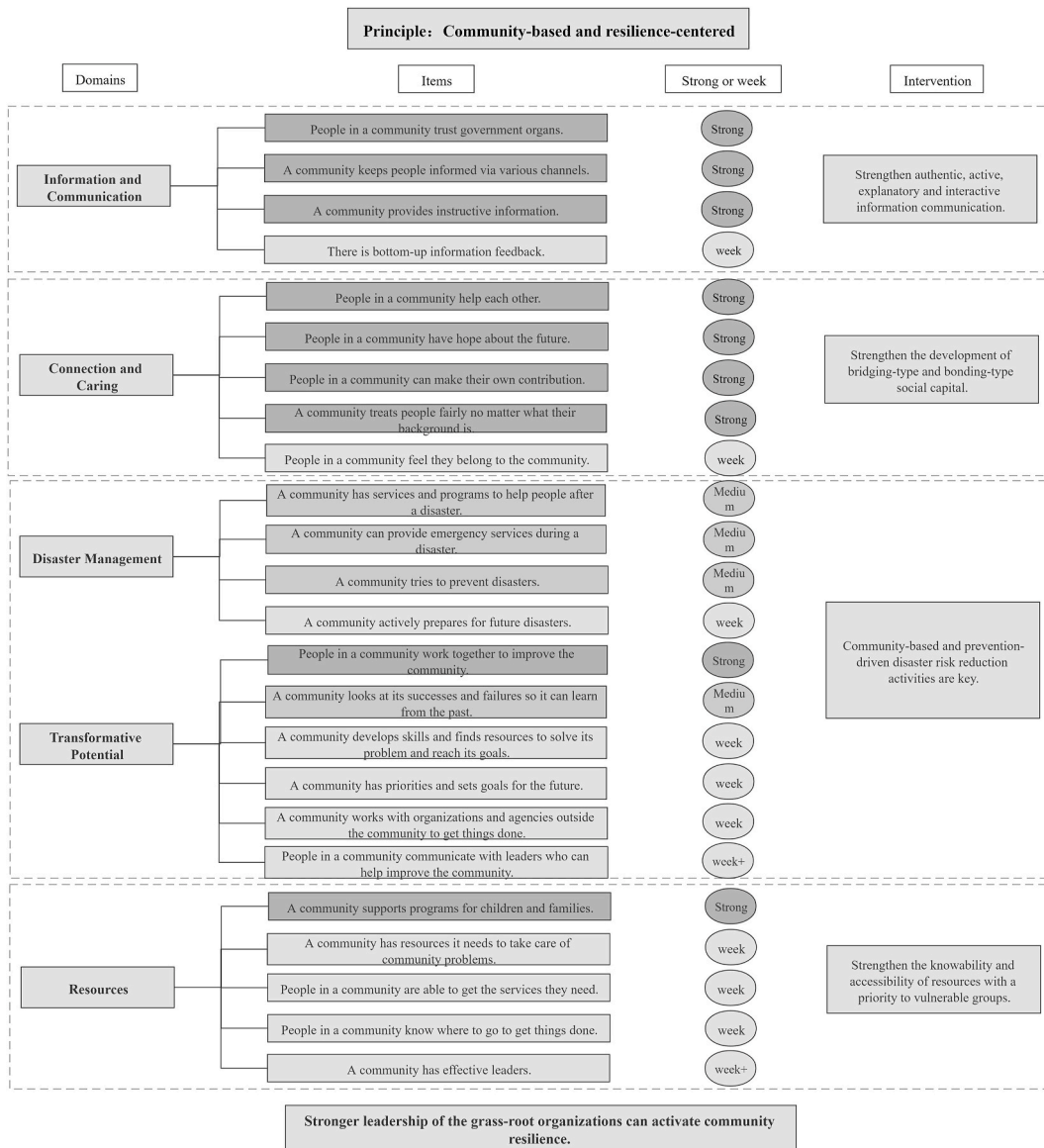


Fig. 2. Integrated framework for improving community resilience in the post-pandemic era.

6.3. Disaster risk reduction activities based on community-level participation and prevention are the key influencing factors that can be well managed to strengthen community resilience

Past experience and knowledge has proven that targeted strategic planning for current risks and policies for future responses to potential public emergencies by the government is the core for community resilience [73]. Among them, the focus of prevention strategy is on the participation of local communities and residents in the whole process. This means that communities should participate in risk assessment, response planning, capacity building, implementation and establishment of disaster detection systems, and that community residents should be given more opportunities to acquire information, knowledge, resources and enjoy basic social services [68].

The most effective way to improve resilience to disasters is to provide targeted training on the knowledge, attitudes, preparations and skills of disaster prevention according to the specific situation of a community, and carry out disaster prevention drills [74,75]. Community workshops, publicity efforts, drills, community alliances, seminars are among the most effective intervention measures for community disaster prevention [76]. In addition, if disaster prevention education can be combined with community capital (community connection), community residents will be more willing to continuously prepare for emergency prevention in their family or the community they live in Ref. [77].

Therefore, in the post-pandemic era, it is urgent to conscientiously learn from both successful experience and shortcomings during the COVID-19 pandemic, so as to develop sound and standardized training, and improve the ability of residents, community leaders,

governments at all levels and disaster relief professionals through training, drills and other diversified methods. This is the key to improving community resilience.

6.4. The development of a community resource system, which focuses on vulnerable groups, residents are aware of and have access to, is the basic guarantee for improving the community resilience

Community resilience, to some extent, is decided by whether the most vulnerable members can be taken good care of. Disasters and crises may happen as a result of unequal distribution of opportunities and social inequality, which is very likely to put these vulnerable groups at high risks. The ability of these vulnerable groups to cope with and emerge from disasters are also relatively weak. In addition, if government departments or other aid groups carry out rescue efforts in a one-size-fits-all approach, then individual differences and the specific needs of the vulnerable groups will be ignored. Such rescue efforts will also lead to social unfairness [78]. Therefore, effective humanitarianism-based disaster relief should provide relief materials to those who most need them at the right time, in the right place and in the right quantity [79].

An effective resource management mechanism not only provides abundant, diverse and high-quality resources, but also allocates these resources firstly to vulnerable groups in more vulnerable areas [80]. But the respondents of this study gave relatively lower scores to the quantity, awareness and accessibility of resources, with the three items "My community has resources it needs to take care of community problems", "People in my community are able to get the services they need.", and "People in my community know where to go to get things done." scoring 3.73, 3.72 and 3.69 with percentages of agreement at 58.15%, 59.54% and 57.69% respectively. Therefore, it is necessary to develop a resource management system residents are aware of and have access to. Such a system should also give priority to vulnerable groups.

6.5. A connection and caring system based on the bonding, bridging, and linking-type community capital provides strong support for enhancing community resilience

Although external crisis can promote collective altruistic actions within the community (residents) in the short term, a resilient community should be equipped with a stable, lasting and profound social capital system. In a top-down social governance model, strong leadership at the community level is more conducive to enhancing linking-type social capital, but it contributes little to promoting bonding-type social capital and enhancing the participation of community residents [81].

To improve community resilience in the post-pandemic era, the bonding, bridging and linking-type community capital should be strengthened. Grass-roots social workers can enhance the community capital through different levels of intervention services. Different leisure and entertainment activities can strengthen the communication between different groups in a community, so as to enhance the bonding-type capital. Through the discussions on how to prevent and solve disasters, and the establishment of community disaster alliances, the cooperation among different groups in the community can be promoted to achieve common goals, thus enhancing the bridging-type capital. Through the cultivation of community leaders, we can promote the cooperation between community residents and formal community organizations, including government agencies, non-governmental organizations, financial institutions, professional disaster prevention agencies or volunteer teams, etc., so as to strengthen the linking-type capital, mitigate the impacts of disasters, and emerge from disasters as soon as possible [82].

6.6. A flexible and rapid "information communication system" based on both the top-down and bottom-up approaches is an effective way to enhance community resilience

Information communication is one of the core issues for disaster and risk management, which is especially the case during the COVID-19 pandemic, a public health crisis involving professional knowledge. For effective communication, information to be shared should be authentic and interactive and be explained actively to the residents [83]. Being interactive means that there should be both top-down information dissemination, bottom-up feedback as well as information exchange between residents.

This study proves that information communication was highly effective during the COVID-19 pandemic. On the one hand, government departments and professional institutions took the initiative to publicize pandemic prevention information in clear and plain language. At the same time, online information-sharing platforms also greatly improved the efficiency of information transmission in a timely manner. Efficient information dissemination enhanced people's trust and confidence in government departments, and also laid a solid foundation for the follow-up pandemic prevention and control responses.

It should be noted that compared with the top-down information reception which is only one-way and in a passive manner, the bottom-up feedback is a more effective way to understand what really happens. Therefore, it is a direct channel through which people in a community can participate actively in pandemic prevention and control. Therefore, building a resilient community also requires a bottom-up and parallel interactive approach so as to collect as many as possible opinions and suggestions, including those from the vulnerable and marginalized groups in a community [3]. This should be the direction for improvement so as to enhance community resilience in the post-pandemic era.

In conclusion, This study systematically presents a big picture of how communities responding to the pandemic at the early stage by using a CART-based bottom-up approach. The findings indicate that compared with static sociodemographic factors, participation in community-based volunteer responder groups and disaster risk reduction activities exert more significant impact on community resilience. In the post-pandemic era, when "we may have to coexist with COVID-19", the findings of this study provide inspirations for both policy formulation and practical intervention for community-based pandemic prevention and control. In addition, the "community-based, and resilience-centered" integrated framework for improving community resilience could also be taken as a reference for those working at the primary level.

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Conflicts of interest/Competing interests

The author declares that there is no conflict of interests regarding the publication of this article.

Availability of data and material

All data, models, or code generated are available from the author by request.

Code availability

Software application is STATA.

Authors' contributions

Not applicable.

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.

References

- [1] I. Alcántara-Ayala, I. Burton, A. Lavell, E. Mansilla, A. Maskrey, A. Oliver-Smith, F. Ramírez-Gómez, Editorial: root causes and policy dilemmas of the COVID-19 pandemic global disaster, *International Journal of Disaster Risk Reduction* 52 (2021), <https://doi.org/10.1016/j.ijdr.2020.101892>, 101892-101892.
- [2] Hans Henri P. Kluge, Statement – older people are at highest risk from COVID-19, but all must act to prevent community spread, in: Copenhagen: WHO Regional Office for Europe, 2020. <https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/statements/statement-older-people-are-at-highest-risk-from-covid-19,-but-all-must-act-to-prevent-community-spread>.
- [3] J. South, J. Stansfield, R. Amlôt, D. Weston, Sustaining and strengthening community resilience throughout the COVID-19 pandemic and beyond, *Perspectives in Public Health* 140 (6) (2020) 305–308.
- [4] Public Health England, Community-centred Public Health: Taking a Whole System Approach: Briefing of Research Findings, Public Health England, "London, 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/857029/WSA_Briefing.pdf.
- [5] National Health Commission of the People's Republic of China, Notice on Strengthening Community Prevention and Control of the COVID-19 Pandemic (Issued by Joint Prevention and Control Mechanism, 2020, [2020] No.5). http://www.gov.cn/xinwen/2020-01/26/content_5472235.htm.
- [6] L. Zhang, J. Zhao, J. Liu, K. Chen, Community disaster resilience in the COVID-19 outbreak: insights from shanghai's experience in China, *Risk Manag. Healthc. Pol.* 13 (2021) 3259–3270.
- [7] Kathleen Sherrieb, Fran H. Norris, Sandro Galea, Measuring capacities for community resilience, *Soc. Indic. Res.* 99 (2) (2010) 227–247.
- [8] Erio Ziglio, Strengthening resilience: a priority shared by Health 2020 and the sustainable development goals, Copenhagen: WHO Regional Office for Europe (2017). https://www.euro.who.int/_data/assets/pdf_file/0005/351284/resilience-report-20171004-h1635.pdf.
- [9] D.E. Alexander, Resilience and disaster risk reduction: an etymological journey, *Nat. Hazards Earth Syst. Sci.* 13 (11) (2013) 2707–2716, <https://doi.org/10.5194/nhess-13-2707-2013>.
- [10] David M. Abramson, Lynn M. Grattan, Brian Mayer, E. Colten Craig, Farah A. Arosemena, Ariane Bedimo-Rung, Maureen Lichtveld, The resilience activation framework: a conceptual model of how access to social resources promotes adaptation and rapid recovery in post-disaster settings, *J. Behav. Health Serv. Res.* 42 (1) (2015) 42–57.
- [11] Peter Timmerman, Vulnerability, resilience and the collapse of society: a review of models and possible climatic applications, *Environmental Monograph* (1981), 1. <http://www.ilankelman.org/miscellany/Timmerman1981.pdf>, Institute for Environmental Studies, University of Toronto.
- [12] James M. Kendra, Tricia Wachtendorf, Elements of resilience after the world trade center disaster: reconstituting New York city's emergency operations centre, *Disasters* 27 (1) (2003) 37–53.
- [13] Patricia H. Longstaff, Nicholas J. Armstrong, Keli Perrin, Whitney M. Parker, Matthew Hidek, Building resilient communities: a preliminary framework for assessment, *Homel. Secur. Aff.* 6 (3) (2010).
- [14] S.B. Manyena, The concept of resilience revisited, *Disasters* 30 (4) (2006) 434–450.
- [15] Geoff A. Wilson, Community resilience and social memory, *Environ. Val.* 24 (2) (2015) 227–257.
- [16] Sonny S. Patel, M. Brooke Rogers, Richard Amlôt, G. James Rubin, What do we mean by 'community resilience'? A systematic literature review of how it is defined in the literature, *PLoS Currents* 9 (2017).
- [17] Betty Pfefferbaum, Richard L. Horn, Rose L. Pfefferbaum, A conceptual framework to enhance community resilience using social capital, *Clin. Soc. Work. J.* 45 (2) (2017) 102–110.
- [18] Douglas Paton, Marian Millar, David Johnston, Community resilience to volcanic hazard consequences, *Nat. Hazards* 24 (2) (2001) 157–169.
- [19] Louise Lemyre, Mélanie Clément, Wayne Corneil, Lorraine Craig, Boutette Paul, Michael Tyshenko, Nataliya Karyakina, Robert Clarke, Daniel Krewski, GAP-Santé Research Team, A psychosocial risk assessment and management framework to enhance response to CBRN terrorism threats and attacks, *Biosecurity and Bioterrorism* 3 (4) (2005) 316–330.
- [20] Fran H. Norris, Susan P. Stevens, Betty Pfefferbaum, Karen F. Wyche, Rose L. Pfefferbaum, Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness, *Am. J. Community Psychol.* 41 (1) (2008) 127–150.
- [21] Robin S. Cox, Karen-Marie Elah Perry, Like a fish out of water: reconsidering disaster recovery and the role of place and social capital in community disaster resilience, *Am. J. Community Psychol.* 48 (3) (2011) 395–411.
- [22] Carl Gibson, An integrated approach to managing disruption-related risk: life and death in a model community, *J. Bus. Continuity Emerg. Plan.* 4 (3) (2010) 246–261.
- [23] Samed Bulbulia, Seedat Mohamed, Rashid Ahmed, Ashley Van Niekerk, Discerning community resilience in disadvantaged communities in the context of violence and injury prevention, *S. Afr. J. Psychol.* 34 (3) (2004) 386–408.
- [24] Eve Coles, Philip Buckle, Developing community resilience as a foundation for effective disaster recovery, *Aust. J. Emerg. Manag.* 19 (4) (2004) 6–15.
- [25] Susan L. Cutter, Lindsey Barnes, Berry Melissa, Christopher Burton, Elijah Evans, Eric Tate, Jennifer Webb, A place-based model for understanding community resilience to natural disasters, *Global Environ. Change* 18 (4) (2008) 598–606.

- [26] Abbas Ostadtaghizadeh, Ardalan Ali, Paton Douglas, Jabbari Hossain, Hamid Reza Khankeh, Community disaster resilience: a systematic review on assessment models and tools, *PLoS Currents* 7 (2015).
- [27] Odeya Cohen, Arkady Bolotin, Mooli Lahad, Avishay Goldberg, Limor Aharonson-Daniel, Increasing sensitivity of results by using quantile regression analysis for exploring community resilience, *Ecol. Indic.* 66 (2016) 497–502.
- [28] Kreg Lindberg, Tommy Swearingen, A reflective thrive-oriented community resilience scale, *Am. J. Community Psychol.* 65 (3–4) (2020) 467–478.
- [29] C. Béné, Towards a quantifiable measure of resilience, in: Working Paper (University of Sussex. Institute of Development Studies), vol. 434, 2013, pp. 1–27, <https://doi.org/10.1111/j.2040-0209.2013.00434.x>.
- [30] Elena Serfilippi, Gayatri Ramnath, Resilience measurement and conceptual frameworks: a review of the literature, *Ann. Publ. Cooper. Econ.* 89 (4) (2018) 645–664.
- [31] Susan L. Cutter, The landscape of disaster resilience indicators in the USA, *Nat. Hazards* 80 (2) (2016) 741–758.
- [32] Ayyoob Sharifi, A critical review of selected tools for assessing community resilience, *Ecol. Indic.* 69 (2016) 629–647.
- [33] Michael Ungar, The social ecology of resilience: addressing contextual and cultural ambiguity of a nascent construct, *Am. J. Orthopsychiatry* 81 (1) (2011) 1–17.
- [34] Anita Chandra, Malcolm Williams, Alonzo Plough, Alix Stayton, B. Kenneth, Wells Mariana Horta, Jennifer Tang, Getting actionable about community resilience: the los angeles county community disaster resilience project, *Am. J. Publ. Health* 103 (7) (2013) 1181–1189.
- [35] Rose L. Pfefferbaum, Betty Pfefferbaum, Nitiéma Pascal, J. Brian Houston, Richard L. Van Horn, Assessing community resilience: an application of the expanded CART survey instrument with affiliated volunteer responders, *Am. Behav. Sci.* 59 (2) (2015) 181–199.
- [36] Lucy Faulkner, Katrina Brown, Tara Quinn, Analyzing community resilience as an emergent property of dynamic social-ecological systems, *Ecol. Soc.* 23 (1) (2018) 24.
- [37] Emilie Alirol, Laurent Getaz, Beat Stoll, François Chappuis, Louis Louta, Urbanisation and infectious diseases in a globalised world, *Lancet Infect. Dis.* 11 (2) (2011) 131–141.
- [38] O. Alonge, S. Sonkarlay, W. Gwaikolo, C. Fahim, J.L. Cooper, D.H. Peters, Understanding the role of community resilience in addressing the Ebola virus Disease epidemic in Liberia: a qualitative study (community resilience in Liberia), *Glob. Health Action* 12 (1) (2019), 1662682-1662682.
- [39] Eric Klinenberg, *Palaces for the People: How Social Infrastructure Can Help Fight Inequality, Polarization, and the Decline of Civic Life*, Broadway Books, Portland, 2018.
- [40] R. Djalante, Rajib Shaw, Andrew DeWit, Building resilience against biological hazards and pandemics: COVID-19 and its implications for the sendai framework, *Progress in Disaster Science* 6 (2020) 100080.
- [41] William Hynes, Benjamin Trump, Patrick Love, Igor Linkov, Bouncing forward: a resilience approach to dealing with COVID-19 and future systemic shocks, *Environment Systems and Decisions* 40 (2) (2020) 174–211.
- [42] Cary Wu, Social capital and COVID-19: a multidimensional and multilevel approach, *Chinese Sociological Review* 53 (1) (2021) 27–54.
- [43] Dmitry Leykin, Mooli Lahad, Odeya Cohen, Avishay Goldberg, Limor Aharonson-Daniel, Conjoint community resiliency assessment measure-28/10 items (CCRAM28 and CCRAM10): a self-report tool for assessing community resilience, *Am. J. Community Psychol.* 52 (3) (2013) 313–323.
- [44] GOAL, Analysis of the Resilience of Communities to Disasters (ARC-D) Toolkit User Guidance Manual, 2016. https://resiliencenexus.org/arc_d_toolkit/what-it-is/.
- [45] Aaron Clark-Ginsberg, Bernard McCaul, Isabelle Bremaud, Gabriela Cáceres, Desire Mpanje, Sonny Patel, Ronak Patel, Practitioner approaches to measuring community resilience: the analysis of the resilience of communities to disasters Toolkit, *International Journal of Disaster Risk Reduction* 50 (2020) 101714.
- [46] UNDP, Understanding Community Resilience: Findings from Community-Based Resilience Analysis (CoBRA) Assessments, UNDP Drylands Development Centre, 2014. https://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_land_management/CoBRA/CoBRA_assessment.html.
- [47] Jonathan M. Links, Brian S. Schwartz, Lin Sen, Norma Kanarek, Judith Mitrani-Reiser, Tara Kirk Sell, Crystal R. Watson, et al., COPEWELL: a conceptual framework and system dynamics model for predicting community functioning and resilience after disasters, *Disaster Med. Public Health Prep.* 12 (1) (2018) 127–137.
- [48] Monica Schoch-Spana, Kimberly Gill, Divya Hosangadi, Cathy Slempp, Robert Burhans, Janet Zeis, Eric G. Carbone, Jonathan Links, The COPEWELL rubric: a self-assessment Toolkit to strengthen community resilience to disasters, *Int. J. Environ. Res. Publ. Health* 16 (13) (2019) 2372.
- [49] Rose L. Pfefferbaum, Richard L. Betty Pfefferbaum, Horn Van, Richard W. Klomp, Fran H. Norris, Dori B. Reissman, The communities advancing resilience Toolkit (CART): an intervention to build community resilience to disasters, *J. Publ. Health Manag. Pract.* 19 (3) (2013) 250–258.
- [50] Susan L. Cutter, Community resilience, natural hazards, and climate change: is the present a prologue to the future? *Nor. Geografisk Tidsskr.* 74 (3) (2020) 200–208.
- [51] L. Olsson, A. Jerneck, H. Thoren, J. Persson, D. O'Byrne, Why resilience is unappealing to social science: theoretical and empirical investigations of the scientific use of resilience, *Science Advances* 1 (4) (2015), <https://doi.org/10.1126/sciadv.1400217>, e1400217-e1400217.
- [52] A. Titz, T. Cannoin, F. Krüger, Uncovering 'community': challenging an elusive concept in development and disaster related work, *Societies* 8 (3) (2018), <https://doi.org/10.3390/soc8030071>.
- [53] D. MacKinnon, K.D. Derickson, From resilience to resourcefulness: a critique of resilience policy and activism, *Prog. Hum. Geogr.* 37 (2) (2013) 253–270, <https://doi.org/10.1177/0309132512454775>.
- [54] F. Miller, H. Osbahr, E. Boyd, F. Thomalla, S. Bharwani, G. Ziervogel, B. Walker, J. Birkmann, S. van der Leeuw, J. Rockström, J. Hinkel, T. Downing, C. Folke, D. Nelson, Resilience and vulnerability: complementary or conflicting concepts? *Ecol. Soc.* 15 (3) (2010) 11, <https://doi.org/10.5751/ES-03378-150311>.
- [55] J.A. Patel, F.B.H. Nielsen, A.A. Badiani, S. Assi, V.A. Unadkat, B. Patel, R. Ravindrane, H. Wardle, Poverty, inequality and COVID-19: the forgotten vulnerable, *Public Health (Lond.)* 183 (2020) 110–111, <https://doi.org/10.1016/j.puhe.2020.05.006>.
- [56] C. Béné, R.G. Wood, A. Newsham, M. Davies, Resilience: new utopia or new tyranny? reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes, in: Working Paper (University of Sussex. Institute of Development Studies), vol. 405, 2012, pp. 1–61, <https://doi.org/10.1111/j.2040-0209.2012.00405.x>, 2012.
- [57] Rose L. Pfefferbaum, Betty Pfefferbaum, D. Zhao Yan, Van Horn Richard L, Grady S. "Mack" McCarter, Michael B. Leonard, Assessing community resilience: a CART survey application in an impoverished urban community, *Disaster Health* 3 (2) (2016) 45–56.
- [58] Kinanthi, Melok Roro, Novika Grasiawaty, Yulistin Tresnawaty, Resiliensi pada mahasiswa di jakarta: menilik peran komunitas, *Personalführung* 9 (2) (2020) 249–268.
- [59] de Deuge, Ha Hoang Josephine, Katherine Kent, Jonathon Mond, Heather Bridgman, Sarah Skromanis, Laura Smith, Auckland Stuart, Impacts of community resilience on the implementation of a mental health promotion program in rural Australia, *Int. J. Environ. Res. Publ. Health* 17 (6) (2020) 2031.
- [60] M. Hu, Y. Hao, Ni Ning, Q. Wu, X. Han, B. Zheng, Y. Yu, Z. Chen, Reliability and validity evaluation of Chinese community resistance scale (CART), *Chin. J. Public Health* 33 (2017) 707–710, 05.
- [61] Ke Cui, Ziqiang Han, Dongming Wang, Resilience of an earthquake-stricken rural community in southwest China: correlation with disaster risk reduction efforts, *Int. J. Environ. Res. Publ. Health* (3) (2018) 407.
- [62] W. Zhou, N. Ning, Y. Zhou, J. Qiao, Y. Hao, Q. Wu, A qualitative study on the emergency management mechanism of COVID-19 in village F from the perspective of community resilience, *Chinese Rural Health Service Administration* 41 (2021) 64–67, 01.
- [63] A.J. Faas, E.K. Marino, Mythopolitics of 'community': an unstable but necessary category, *Disaster Prev. Manag.* 29 (4) (2020) 481–484.
- [64] Kristen Magis, Community resilience: an indicator of social sustainability, *Soc. Nat. Resour.* 23 (5) (2010) 401–416.
- [65] Daniel P. Aldrich, Michelle A. Meyer, Social capital and community resilience, *Am. Behav. Sci.* 59 (2) (2015) 254–269.
- [66] Tim Prior, Christine Eriksen, Wildfire preparedness, community cohesion and social-ecological systems, *Global Environ. Change* 23 (6) (2013) 1575–1586.
- [67] Jia Miao, Donglin Zeng, Zhilei Shi, Can neighborhoods protect residents from mental distress during the COVID-19 pandemic? Evidence from wuhan, *Chinese Sociological Review* 53 (1) (2021) 1–26.
- [68] Andrew Maskrey, Revisiting community-based disaster risk management, *Environ. Hazards* 10 (1) (2011) 42–52.

- [69] F. Zhang, Reflection on local experience and development of practical model for disaster social work: from the perspective of disaster resilience theory, *J. Yunnan Normal Univ.* 48 (2016) 83–91, 05.
- [70] Laurie E. Paarlberg, Megan LePere-Schloop, Marlene Walk, Jin Ai, Yue Ming, Activating community resilience: the emergence of COVID-19 funds across the United States, *Nonprofit Voluntary Sect. Q.* 49 (6) (2020) 1119–1128.
- [71] Wenping Xu, Lingli Xiang, David Proverbs, Shu Xiong, 2021, "the influence of COVID-19 on community disaster resilience, *Int. J. Environ. Res. Publ. Health* 18 (1) (2020) 88.
- [72] Y. Yu, C. Wu, X. Tan, B. Zhao, Urban resilient community construction and planning response, *Planner* 36 (2020) 94–97, 06.
- [73] Deseraí A. Crow, Elizabeth A. Albright, Ely Todd, Elizabeth Koebele, Lydia Lawhon, Do disasters lead to learning? Financial policy change in local government: do disasters lead to learning? *Rev. Pol. Res.* 35 (4) (2018) 564–589.
- [74] Elizabeth Frankenberg, Bondan Sikoki, Cecep Sumantri, Wayan Suriastini, Thomas Duncan, Education, vulnerability, and resilience after a natural disaster, *Ecol. Soc.* 18 (2) (2013), 16–16.
- [75] J.S. Semien, K.A.P.S.: a disaster training approach for high-risk communities, *Int. J. Mass Emergencies Disasters* 37 (3) (2019) 264–285.
- [76] Barbara Ryan, Kim A. Johnston, Maureen Taylor, McAndrew Ryan, Community engagement for disaster preparedness: a systematic literature review, *International Journal of Disaster Risk Reduction* 49 (2020) 101655.
- [77] Eva (Evalyna) A. Bogdan, Ashley M. Roszko, Mary A. Beckie, Conway Adam, We'Re ready! Effectiveness of community disaster preparedness workshops across different community groups in alberta, Canada, *International Journal of Disaster Risk Reduction* 55 (2021) 102060.
- [78] F. Zhang, Y. Zhang, Functional review and professional capacity enhancement of disaster social work, *J. East China Univ. Sci. Technol.* 28 (2013) 98–106, 06.
- [79] Douglas Alem, Hector F. Bonilla-Londono, Ana Paula Barbosa-Povoa, Relvas Susana, Ferreira Deisemara, Moreno Alfredo, Building disaster preparedness and response capacity in humanitarian supply chains using the social vulnerability index, *Eur. J. Oper. Res.* 292 (1) (2021) 250–275.
- [80] Susan L. Cutter, Bryan J. Boruff, W. Lynn Shirley, Social vulnerability to environmental hazards, *Soc. Sci. Q.* 84 (2) (2003) 242–261.
- [81] Jan Franssen, Daniela Ochoa Peralta, Francesca Vanelli, Jurian Edelenbos, The Emergence of Urban Community Resilience Initiatives during the COVID-19 Pandemic: an International Exploratory Study, *The European Journal of Development Research*, 2021, <https://doi.org/10.1057/s41287-020-00348-y>.
- [82] Golam M. Mathbor, Enhancement of community preparedness for natural disasters: the role of social work in building social capital for sustainable disaster relief and management, *Int. Soc. Work* 50 (3) (2007) 357–369.
- [83] J. Cao, L. Cao, Information communication and management under public health emergencies, " *Social Sciences in Nanjing* 4 (2020) 98–1054.