

ORIGINAL ARTICLE

Community centered public safety resilience under public emergencies: A case study of COVID-19

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Abstract

During public emergencies, the level of public safety will be resilient and follow a process from decline to rise. Regarding the concept and influencing factors of public safety resilience, a three-level public safety resilience framework that includes personal, community, and government levels was proposed in this study. It provided the overall metrics that used the resistance and recovery ability to describe the dynamic characteristics of public safety resilience as well as the resilience assessment indexes on three levels. In the context of the Coronavirus Disease 2019 (COVID-19) pandemic, this study applied the proposed framework in a case study on public safety resilience at the Beihang community, Beijing, China through descriptive statistics, structural equation model, and principal component regression analysis of questionnaire data. The data analysis results showed that community resilience was the most important of the three levels of public safety resilience. In addition, community resilience could improve personal resilience, and government resilience had a positive effect on community and personal resilience. Compared with the resistance ability, the recovery ability was influenced more by the operation and improvement of the community. This study is conducive to understanding and improving public safety resilience on the personal, community, and government levels and can help relevant parties improve their ability to respond to the COVID-19 pandemic. Furthermore, the methods used in this study can be extended to other studies on public emergencies.

KEYWORDS

COVID-19, public safety, resilience

1 | INTRODUCTION

Because of their suddenness and destructiveness, public emergencies often bring substantial economic losses to society and even cause a large number of casualties. As the time and place of public emergencies are largely unpredictable, people pay increasingly more attention to enhancing the society's ability to resist and recover from public emergencies (Adger et al., 2005; Saja et al., 2019). Scholars and practitioners have introduced the concept of resilience into the public safety management process to improve society's ability to respond to various accidents and disasters (Mcmanus et al., 2007; Tobin, 1999).

The resilience theory stems from the ability of a material to return to its original state after being deformed by external forces (Leykin et al., 2016). Holling introduced the resilience

theory to the study of ecosystems to measure the ability of ecosystems to recover to a stable state after absorbing disturbances (Holling, 1973). After Holling, scholars introduced resilience from natural ecosystems to social ecosystems to study the ability of social systems to eliminate adverse effects and gradually recover from climate disasters (Smith, 1981). With the deepening of the understanding of resilience, it was found that the traditional concept of resilience presupposing a single steady state of the system cannot explain the problems in social fields well. Therefore, Holling revised the previous definition of resilience with the thought that the system can absorb many disturbances before changing its own structure and emphasized that the system can have multiple stable states (Holling, 1996). With the development of adaptive cycle theory, resilience is considered to be the ability of a complex social ecosystem to adapt and change in response

to pressure. Some scholars proposed that there is no stable state in the system, and what resilience emphasizes is that the system can adapt to the changing environment through continuous changes (Holling & Gunderson, 2002; Walker et al., 2004). Since then, research on the resilience of social systems has continued to increase. Scholars in different fields, such as organizational system (Vogus & Sutcliffe, 2007), safety systems (Dinh et al., 2012), critical infrastructure systems (Shafieezadeh & Ivey Burden, 2014), city resilience (Bastaminia et al., 2017), and community resilience (Leykin et al., 2016), adopted this different point of view to define the concept of “resilience,” focusing on the resistance and recovery of the system, community, or group under emergencies.

The above studies on social and system resilience all have one thing in common, that is, they focus on the resistance and recovery of the system, community, or group under emergencies. In the field of public safety, the application of resilience theory has also become a focus of researchers who aim to enhance public resistance and recovery in response to public emergencies. Some of them underlined that the following two points should be considered (Bastaminia et al., 2017; de Groot et al., 2010; Madni & Jackson, 2011):

1. Defining resilience and determining the level. Public emergencies involve different levels such as individuals, families, groups, communities, countries, and even the world. Choosing the appropriate level to define resilience is very important for subsequent research.
2. Defining the components and measures of resilience. The definitions of resilience at different levels are different, so are the components that constitute resilience. Even at the same level, for different types of public emergencies, there are substantial differences in the composition and measurement of resilience.

At present, a major public health emergency that confronts the world is the COVID-19 pandemic, which has been seriously harming people's lives and health and causing a major blow to the global economy. The World Health Organization (WHO) announced that the COVID-19 became a pandemic on March 11, 2020 (World Health Organization, 2020b). By March 18, 2020, a cumulative total of 80,928 confirmed cases had been reported on the China's mainland, 70,420 infected patients had been cured and discharged from hospital, and 3245 people had died (National Health Commission of the PRC, 2020). Among them, a total of 415 local confirmed cases and nine deaths were reported in Beijing (Beijing Municipal Health Commission, 2020). On March 18, there were only 34 new confirmed cases and eight new deaths in Chinese mainland (National Health Commission of the PRC, 2020). The numbers suggested that China had gone through the hardest time during the pandemic and the situation of epidemic prevention and control was getting better. People's production and living order was being restored, and the public was full of confidence and hope for the restoration and improvement of public safety in the future.

There has been a lack of systematic and comprehensive research in public health emergencies like the COVID-19 pandemic from the perspective of public safety resilience. Bloomberg released the Covid resilience ranking, which is mainly based on data on infections, medical assistance, economic growth, and community mobility (Bloomberg, 2021), and scored the 53 economies that had successfully contained the pandemic with the least social and economic disruption. However, this indicator fails to fully reflect the connotation of resilience in terms of recovering from interference. To fill this gap, this research took the Beihang community during the current COVID-19 pandemic as an example to analyze the factors that affect the public safety resilience in public health events from the perspective of resistance and recovery. This paper is organized as follows: Section 2 introduces the concept and the evaluation index of public safety resilience. Section 3 provides the purpose and hypothesis of empirical research, questionnaire design, and survey scheme. In Section 4, six hypotheses in the theoretical model are tested by the calculation and analysis of the questionnaire data. Section 5 presents the main conclusions of the paper.

2 | PUBLIC SAFETY RESILIENCE

2.1 | The concept of public safety resilience

This study uses the concept of public safety resilience to explain the public capacity under public emergencies, a case study is conducted with COVID-19 as the object in the follow-up study. For certain groups or regions, the level of public safety will decrease with the occurrence of public emergencies and increase with their end, and the public's perception of their safety in a fixed environment can be a good measure of this change. Therefore, this study defines public safety resilience as *the ability of the public to weaken the impacts of public emergencies, quickly absorb the impacts, restore the expected state of life, and then adapt to future changes with inherent social and economic abilities when safety threats and interference endanger their lives and property*. The framework of public safety resilience constructed in this paper (Figure 1) can be applied to the research of various public emergencies.

Although the public safety resilience is reflected in the public, it is the result of the combination of the resilience of individual, community, and country. These three levels of resilience are defined as follows.

1. Personal resilience: *Personal resilience is the ability of individuals to reduce the adverse effects caused by public emergencies with their own social and economic abilities and external help and recover from the effects as soon as possible*. People are the main body that perceives public safety, so personal resilience can directly reflect public safety resilience.
2. Community resilience: *Community resilience is the ability of a community to resist impacts and recover*

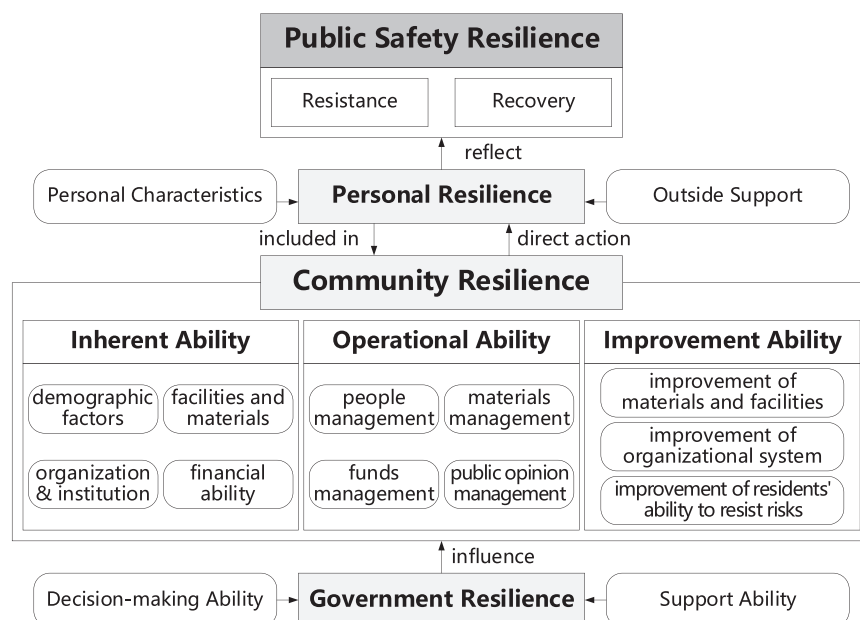


FIGURE 1 Conceptual framework of public safety resilience

from them by using community resources during public emergencies. Community resilience is the core of the public safety resilience framework. The personal socioeconomic background is included in the community's socioeconomic abilities, and the external support that the person can obtain mainly comes from the community's help. Therefore, community resilience directly affects personal resilience, which is one of the important hypotheses that we want to verify through empirical data in this study. In different stages of public emergencies, most researchers have studied three characteristics used to measure the community resilience process: resistance, recovery, and creativity (Cutter et al., 2014; Paton et al., 2014). Resistance is "how people face and overcome immediate threats through directly available resources" (Norris et al., 2008), recovery is "regaining equilibrium" (Wilson et al., 2013), and creativity means that "people can use the experiences to predict risks and adjust their lifestyles" (Lorenz, 2013). These three characteristics of community resilience can be described and measured by the following three abilities.

3. The inherent ability is the inherent attribute of a community under normal conditions. The inherent ability of a community depends on the population factors, facilities, materials, organizational system, and economic ability of the community.
4. The operational ability is the operational resilience shown by the community during public emergencies. In the process of responding to various public emergencies, in addition to the inherent ability of the community, the role of the relevant factors that constitute the inherent ability in the organization, transformation, and scheduling of crisis situations must also be considered.
5. The improvement ability is the ability of the community to improve its resilience through learning and absorbing experience during the recovery process. It depends on

whether the community can learn lessons from this public emergency.

6. Government resilience: *Government resilience is the ability of the government to respond, resist, and adapt to the impacts of public emergencies by taking various government actions.* The government is in a leading position under various emergencies to meet the different needs of the public (Saja et al., 2019; Sapirstein, 2006). As the manager of national resources, the government affects the resilience of the entire society through administrative means when various public emergencies occur (Yonson & Noy, 2020; United Nations, 2005). Therefore, government resilience can influence community and personal resilience, which is also one of the important hypotheses that we want to verify through empirical data in this study.

2.1.1 | The metrics of public safety resilience assessment

Regarding the issue of resilience measurement indicators, many scholars and various international organizations have conducted the studies on the assessment and measurement of social resilience. The assessments and measurements of safety resilience mainly consider vulnerability, risk, and restoration. In 2004, the United Nations Development Program launched a disaster risk indicator that mainly measures earthquakes, tropical cyclones, and floods. Its core is to calculate vulnerability indicators through 26 variables (Peduzzi et al., 2009). In 2005, the International Strategy for Disaster Reduction proposed the Hyogo Action Framework in Tokyo (United Nations, 2005), which identified five priority actions, including system guarantees, monitoring and early warning, knowledge and culture, risk management, and emergency response.

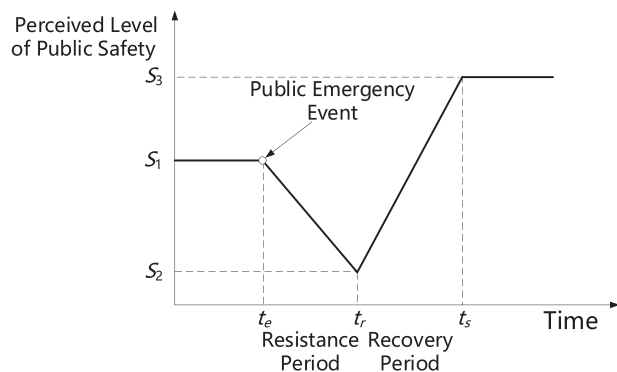


FIGURE 2 Schematic diagram of the process of public safety resilience

On the basis of the existing research, one of the key points of this paper is to measure the public safety resilience. The measurement of resilience is a very important issue in many fields. In the fields of system and engineering resilience, the loss and recovery degree of system performance are mostly used to measure the resistance and recovery ability of the system (Francis & Bekera, 2014). For public safety resilience, we measure it through two dimensions: resistance and recovery for emergencies. Figure 2 describes the public safety resilience process, including the resistance and recovery process of the perceived level of public safety under public emergencies. The vertical axis represents the perceived level of public safety in a certain area, and S_1, S_2 , and S_3 ($S_1 > S_2, S_3 > S_2$) represent the perceived level of public safety in the area before, during and after the occurrence of a public emergency, respectively. The horizontal axis represents the different stages of a public emergency.

In this study, we defined resistance and recovery as follows:

1. **Resistance:** It reflects the changes in the level of public safety that the public perceives before and during public emergencies. The calculation formula is $C1 = \frac{S_2}{S_1}$, where S represents the perceived level of public safety under the normal condition. The greater the ratio, the stronger the resistance.
2. **Recovery:** It reflects the changes in the level of public safety that the public perceives during public emergencies and after they end. The calculation formula is $C2 = \frac{S_3}{S_2}$. The greater the ratio, the stronger the recovery.

2.1.2 | The indexes of public safety resilience assessment

To more accurately measure and evaluate public safety resilience, and analyze the factors that affect public safety resilience, this paper also gives the corresponding evaluation indexes according to the three levels of the public safety resilience framework.

(1) Personal resilience index

The specific indexes of personal resilience are shown in Table 1. The characteristics of people are the basic part of personal resilience, and the direct and main ability to respond to various emergencies, including the personal economic and social background, knowledge and skills to respond to emergencies, and their safety consciousness (Adger et al., 2005; Bastaminia et al., 2017; Cutter et al., 2014). The external support available to a person is the other important part of personal resilience. It stems from people's choice to help each other to overcome difficulties in response to public emergencies (Martin, 2015; Schmidlein et al., 2008) and can be divided into support from one's family and support from other social relationships. The former is based on blood relationships and affection, and its supporting effect is usually stable and continuous. The latter is based on friendships and other relationships in the social system. Its role is often unsustainable, but it cannot be ignored.

(2) Community resilience index

At the community level, there are many studies on resilience indexes (Buikstra et al., 2010; Islam & Walkerdien, 2014; Leykin et al., 2016; Niskanen, 2018; Qasim et al., 2016). The community resilience index in this paper mainly draws on the community disaster resilience index (CDRI). This set of indicators is based on the four stages of the disaster management cycle (preparation, response, recovery, and mitigation) and is determined by combining community capital assets (social, economic, physical, human, and natural capital) (Peacock, 2010). In addition, this paper also refers to the basic resilience indicators for communities (BRIC) constructed from the perspectives of society, economy, system, infrastructure, and community (Cutter et al., 2010) as well as the actual situation of China to finalize the indexes of community resilience (Table 2).

(3) Government resilience index

Government resilience can be expressed from the internal and external perspectives as its own decision-making ability and its support to the community. The level of government decision-making ability depends on whether the government department can quickly and accurately collect and process all kinds of information related to emergencies, and then take relevant measures to command the community to resist the effects of emergencies (Holand et al., 2011; UNISDR, 2015). The government's ability to support the community is reflected in the material and information assistance received by the community. The government resilience indexes are shown in Table 3.

3 | METHODS

3.1 | Research purpose and hypotheses

The purpose of this paper was to study the components and influencing factors of public safety resilience and to understand the relationship among personal resilience, community resilience, and government resilience. In addition, through

TABLE 1 The indexes of personal resilience

First grade index	Second grade index	Explanation
Personal characteristics (X_1)	Economic and social background (X_{11})	Social attributes include age, gender, education, occupation, belief, marriage, etc. Economic attributes include income, insurance, expenditure for safety protection, etc.
	Knowledge and skill (X_{12})	Safety knowledge, self-rescue skills, communication ability, information acquisition ability, etc.
	Safety consciousness (X_{13})	The consciousness of obeying the rules, avoiding risks, self-protection, cooperation and communication, etc.
Outside support (X_2)	Family support (X_{21})	The status of family members, as well as the level of material and spiritual support from family members.
	Other social relations support (X_{22})	The level of material and spiritual support from other social relationships (colleagues, friends, neighbors, etc.).

TABLE 2 The indexes of community resilience

First grade index	Second grade index	Explanation
Inherent ability (X_3)	Demographic factors (X_{31})	The population structure and characteristics of the community; the learning ability, mobility, cultural background, belief, and value recognition of the community residents.
	Facilities and materials (X_{32})	The supply capacity of food, water, electricity, energy, etc.; the guarantee level of rescue, medical, public security, and other professional materials and equipment; the number of hospitals, police stations, and shelters; the traffic convenience in and around the community.
	Organization and institution (X_{33})	System and mechanism related to emergency work; emergency plans and daily drills for various emergencies; organization status related to rescue, medical treatment, charity, and volunteers; communication and trust between different organizations and groups, etc.
	Financial ability (X_{34})	The employment, income, investment, and savings of the community residents; the financial expenditure that the community can use for public security and the funds for emergency rescue.
Operational ability (X_4)	People management (X_{41})	The ability of the community to get active cooperation from residents and maintain their mental health through effective mobilization and organization.
	Materials management (X_{42})	The ability of the community to purchase, store, allocate, and manage all kinds of resources.
	Funds management (X_{43})	The ability of the community to raise funds, receive donations, and other financial support and allocate and manage emergency funds.
	Public opinion management (X_{44})	The ability of the community to gather information from internal and external sources, grasp and guide the public opinion in time, clarify untrue statements, and guide the public psychology in a positive direction.
Improvement ability (X_5)	Improvement of materials and facilities (X_{51})	The ability of the community to improve the storage and management ability of materials and facilities and reasonably plan the community functional areas based on relevant problems exposed by the emergency.
	Improvement of organizational system (X_{52})	The ability of the community to optimize regulations, emergency plans, and processes based on relevant problems exposed by the emergency.
	Improvement of residents' ability to resist risks (X_{53})	The ability of the community to help the residents to improve their ability to respond to risks after the emergency.

TABLE 3 The indexes of government resilience

First grade index	Second grade index	Explanation
Decision-making ability (X_6)	Information collection (X_{61})	The ability of the government to collect information about emergencies from various communities or other countries.
	Command and process (X_{62})	The ability of the government to make accurate judgment on the intelligence information, quickly start a response plan with specific conditions, command across relevant departments, and handle the emergency as a whole.
Support ability (X_7)	Material support (X_{71})	The ability of the government to dispatch professional rescue personnel, materials, and funds to the affected communities and effectively coordinate and allocate resources in different communities.
	Public opinion guidance (X_{72})	The ability of the government to help the community to manage and guide the public opinion, release the correct authoritative information, channel the negative emotions of the residents in the affected community, and realize the information sharing among different communities.

the analysis of the relationship between various variables, this paper also expected to identify the main factors affecting the public safety resilience during public emergencies and discuss how to improve and enhance the abilities of the society and public to cope with the risks brought by public emergencies.

Considering the aforementioned conceptual model and the indexes of public safety resilience, the following hypotheses were proposed.

Hypothesis 1 (H_1): Personal resilience and community resilience affect each other.

Hypothesis 2 (H_2): *Government resilience has a positive effect on community resilience and personal resilience.*

H_{2a} : *Government resilience has a positive effect on community resilience.*

H_{2b} : *Government resilience has a positive effect on personal resilience.*

Hypothesis 3 (H_3): *Among the three levels of resilience, community resilience is the factor that has the greatest impact on public safety resilience.*

Hypothesis 4 (H_4): *Under public emergencies, factors related to materials and facilities have a relatively great impact on public safety resilience.*

Hypothesis 5 (H_5): *Compared with the operational and improvement abilities of the community, the resistance ability is more affected by the inherent ability of the community.*

Hypothesis 6 (H_6): *Compared with the inherent ability of the community, the recovery ability is more affected by the operational and improvement abilities of the community.*

Combined with the proposed conceptual framework and index system of public safety resilience, this paper established a hypothetical prediction model on the basis of preliminary analysis of relevant factors and relations (Figure 3).

3.2 | Design and collection of questionnaires

Questionnaires were used to collect data in this study. Resilience indexes and specific questions related to COVID-19 were determined according to the literature, theoretical research, and guidance from public safety and public health experts. A small-sample presurvey was also carried out to modify and improve the questionnaire content.

Beihang campus and its family community in Haidian District of Beijing were taken as the research area. There were 3491 households with a registered population of 11,213 living in the Beihang family community. The population of the Beihang family community was aging seriously. Notably, 3382 people were aged over 60, accounting for 30.2% of the total community population. By contrast, according to data from the National Bureau of Statistics of China, people aged 60 and over accounted for 18.1% of the total population

of China at the end of 2019 (National Bureau of Statistics of China, 2020). According to the authoritative research, in this COVID-19 outbreak, the infection rate and fatality rate of middle-aged and elderly people were relatively high (Wu et al., 2020). Therefore, taking the Beihang community as the research area was of greater significance for epidemic prevention and control.

The sample size of 980 of this study was determined according to the following formula (Cochran, 1977):

$$n = \frac{Z^2 P(1 - P)}{E^2 + \frac{Z^2 P(1 - P)}{N}}$$

where n was the sample size, Z was the z -statistic, the confidence was 95%, the corresponding Z was 1.96, the margin of error E was set to 3%, P was the probability value of 0.5, and N was the overall population size of 12,000.

From March 18 to March 21, 2020, this study used an electronic questionnaire collection system to collect questionnaires from the predetermined research objects. During this period, the domestic epidemic in China had been effectively controlled, and the Beihang community was in the recovery stage of public safety resilience. There had been no new confirmed cases in the neighborhood for a long time. Community residents found their lives and work on the right track and were full of confidence in the restoration of public safety. The inclusion criteria for the research subjects were: (1) aged over 18; (2) living in the Beihang community when the epidemic occurred; (3) giving informed consent to this study and voluntarily filling out the questionnaire. The questionnaires were distributed to 3642 community residents through social software, and 1079 questionnaires were returned. The response rate was 29.63%. After excluding 87 invalid questionnaires which were not answered in Beijing, incomplete, did not meet the assumption of $S_1 > S_2, S_3 > S_2$, or were answered in less than 200s, 992 valid questionnaires were obtained.

The questionnaire comprised two parts. Part-I had three items with five possible responses graded from 1 to 5. The three items allowed community residents to evaluate the safety level before, during, and after the epidemic based on their actual feelings and existing prevention and control measures, so as to get the value of S_1, S_2 , and S_3 . Part-II had 78 items, covering the three levels of resilience indicators of person, community, and government introduced in Section 2.1. Among them, 31 items were at the personal level, including the basic information of the individual and the ability to respond to the epidemic. Thirty-five items were at the community level, including various factors affecting the epidemic prevention of Beihang community, such as the daily management of the community, epidemic prevention and control measures, and the economics of the community. Ten items were at the government level, including residents' satisfaction with various prevention and control measures taken by the government. Among these items, some of the items about personal basic information were binary or multiple-choice questions, and the rest were Likert scale questions (all Likert

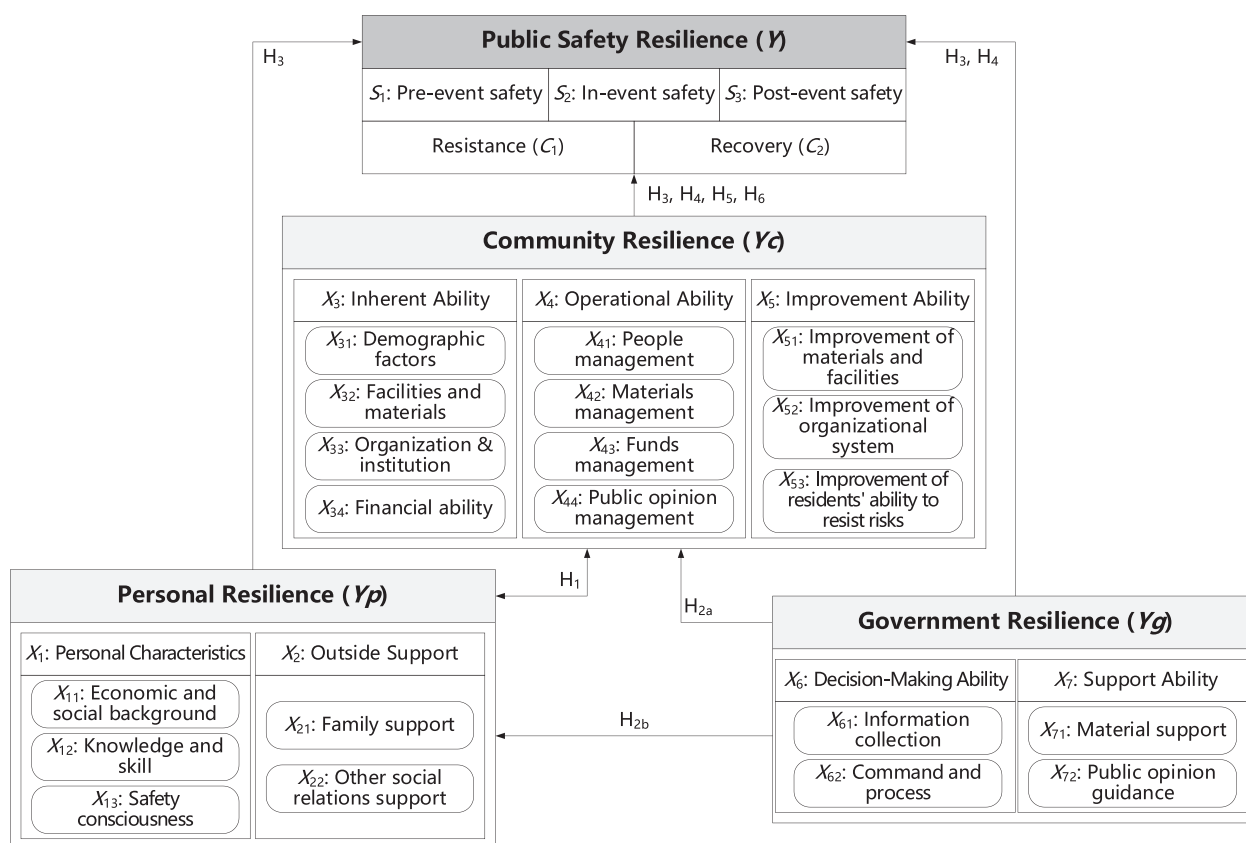


FIGURE 3 Prediction model of public safety resilience

scale questions in this questionnaire were answered as one of the following: 5 = very, 4 = fairly, 3 = average, 2 = not very, and 1 = not).

3.2.1 | Analytical method

This study is based on the consideration of the composition and influencing factors of public safety resilience under COVID-19. The descriptive statistics, structural equation model (SEM), and principal component regression analysis were used to analyze the questionnaire information. All statistical analyses were performed using ©IBM SPSS and AMOS version 24.0.

Descriptive statistics were mainly used to analyze the social and economic characteristics of the participants from the perspective of affecting the public safety resilience. Furthermore, according to the participants' evaluation of the level of community public health and safety, the fluctuation of public safety level under the COVID-19 was drawn.

The SEM was used to analyze the relationship between different variables that affect the public security resilience and test Hypothesis 1 to Hypothesis 4. Based on the theoretical model of public safety resilience proposed in this article and the questionnaire data obtained from the Beihang community, the model contained four latent variables: personal resilience, community resilience, government resilience, and public safety resilience.

The component regression analysis was aimed to identify the main factors affecting the community resilience and test Hypotheses 5 and 6. First, principal component analysis was used to transform the variables related to community resilience into a group of linearly unrelated variables. Then, by taking the extracted main components as independent variables and resistance (C_1) and recovery (C_2) as dependent variables, regression analysis was carried out.

4 | RESULT

4.1 | Descriptive analysis

Through the questionnaire, we collected a sample of 992 residents and staff members from Beihang community. In the descriptive analysis, we assessed the social and economic backgrounds of the respondents.

As shown in Tables 4 and 5, the mean age of the participants was 65.93, and the participants had been in the community for 37.54 years on average. The majority of the respondents had steady incomes (99.3%), and 65.8% held a college degree and higher. The mean frequency of experiencing a public health emergency was 1.2. The results of the study also revealed that the majority of the respondents were in a subhealth state: 59.3% had chronic diseases, and 7.3% had a physical disability.

TABLE 4 Average distribution of social and economic backgrounds of the respondents

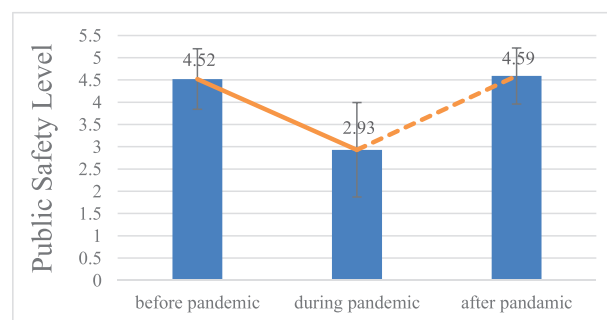
Variable	Mean	SD
Age	65.93	13.73
Mean income (yuan)	7605.45	3189.88
Length of residence in the community (year)	37.54	15.56
Number of public health emergencies experienced	1.20	0.84

TABLE 5 Frequency distribution of social and economic background factors

Variable	Category	Frequency	Percent (%)
Gender	Male	436	44.0
	Female	556	56.0
Education	Primary/Secondary School Diploma	127	12.8
	High school diploma	212	21.4
	College degree	195	19.7
	Bachelor's degree	373	37.6
Steady income	Master's degree and higher	85	8.5
	Yes	985	99.3
	No	7	0.7
Physical disability	Yes	72	7.3
	No	920	92.7
Chronic illness	Yes	588	59.3
	No	404	40.7
Insurance	Yes	959	96.7
	No	33	3.3

The variables can explain the public safety resilience differences in the population related to safety consciousness, knowledge, skills, and economic and social backgrounds, such as income, education, and frequency of experiencing a public health emergency. On the one hand, it can be seen that the average age of residents in this community was relatively old, and most of them suffered from chronic diseases. Therefore, the residents and the community had lower abilities to deal with emergencies and were more likely to become victims of the COVID-19 pandemic. On the other hand, these residents had lived in the community for more than 35 years on average, so the familiar community environment and the relationships between doctors and patients could improve their ability to cope with the epidemic. In addition, higher education levels, stable incomes, and experiences of similar public health emergencies (further investigation shows that the community experienced SARS in 2003) were also conducive to improving the personal resilience of residents.

As shown in Figure 4, the questionnaire participants also evaluated the level of community public health and safety before, during and after the disease based on their own feelings, with the average values of 4.52, 2.93, and 4.59, respectively. And their respective standard deviations were 0.68, 1.06, and 0.63 correspondingly. With the outbreak of

**FIGURE 4** Changes of community public health and safety level

the disease, the residents' perception of the level of public health and safety in the community had declined significantly. Most residents felt that the epidemic had a great negative impact on their lives. However, with the increase in the prevention and control efforts and the recent improvement of the domestic epidemic situation in China, residents had a higher estimate of the level of community public health and safety for the foreseeable future, which was slightly higher than that before the outbreak. This analysis result basically conformed to the public safety resilience process shown in Figure 2.

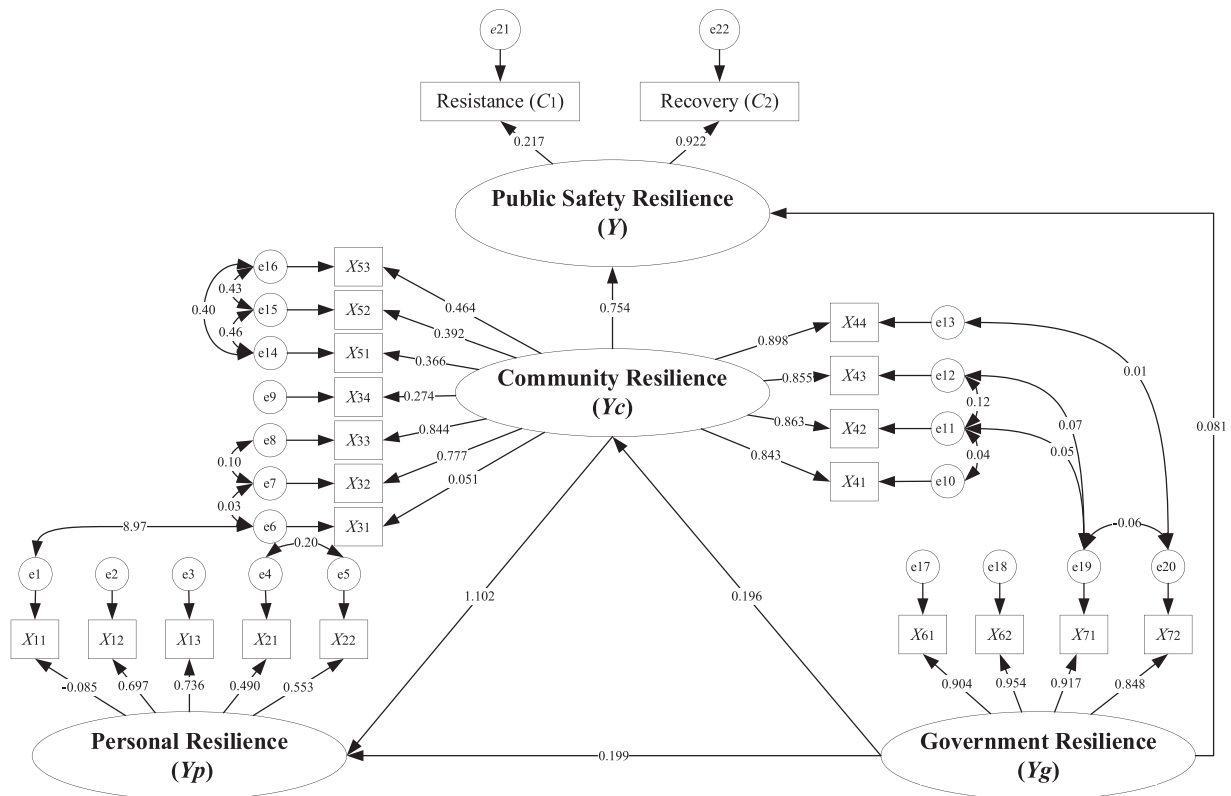


FIGURE 5 Estimation results of structural equation model

TABLE 6 Model fit summary

Fit index	Score	Recommended threshold value
Chi-square test		
χ^2/df	3.149	$\leq 2_a, \leq 5_b$ (McIver & Carmines, 1981)
Fitness index		
GFI	0.938	≥ 0.90 (Hu & Bentler, 1999)
NFI	0.961	≥ 0.90 (Bentler & Bonett, 1980)
PGFI	0.716	≥ 0.50 (Mulaik et al., 1989)
Alternative index		
CFI	0.972	≥ 0.95 (Bentler, 1985)
RMSEA	0.052	≤ 0.08 (McDonald & Ho, 2002)

a: Acceptability: Yes, acceptable; b: Acceptability: Marginal.

4.2 | Structural equation model

The modified SEM and the corresponding path parameters of the impact of individuals, communities and governments on public safety resilience were shown in Figure 5. It should be noted that in the process of calculating the resistance (C_1) and recovery (C_2), S (the public safety level of the community under normal conditions) was approximately replaced by S_I (residents' scores on the level of public safety before the pandemic).

We first tested the fitting effect of SEM. As shown in Table 6, $\chi^2/df = 3.149 < 5$, which showed that the model

fitted well. Among the major fitting indexes of SEM, GFI (goodness-of-fit index) = 0.938 > 0.9, NFI (normed-fit-index) = 0.961 > 0.9, and PGFI (parsimony-goodness-of-fit index) = 0.716 > 0.5. These all further illustrated the ideal fit of the model in this study. In addition, RMSEA (root mean square error of approximation) = 0.052 and CFI (comparative fit index) = 0.972, which meant the fit was acceptable.

Table 7 showed the path parameters between the four latent variables. Compared with the conceptual model (Figure 3), SEM lacked the paths from personal resilience (Y_p) to public safety resilience (Y) and from personal resilience (Y_p) to community resilience (Y_c) due to the lack of significant

TABLE 7 Path coefficient and significance level of latent variables

			Coefficient	SE	Critical ration	<i>p</i>	Hypothesis	Effect	Results
<i>Y</i>	←	<i>Y_p</i>	—	—	—	—	<i>H₃</i>	—	Supported
<i>Y</i>	←	<i>Y_c</i>	0.754	0.273	2.873	***		+	
<i>Y</i>	←	<i>Y_g</i>	0.081	0.022	3.286	***		+	
<i>Y_p</i>	←	<i>Y_c</i>	1.102	0.421	2.760	**	<i>H₁</i>	+	Not Supported
<i>Y_c</i>	←	<i>Y_p</i>	—	—	—	—		—	
<i>Y_p</i>	←	<i>Y_g</i>	0.199	0.062	2.857	**	<i>H_{2a}</i>	+	Supported
<i>Y_c</i>	←	<i>Y_g</i>	0.196	0.056	3.591	***	<i>H_{2b}</i>	+	Supported

***Means relationships are significant at *p*-value < 0.001; **means relationships are significant at *p*-value < 0.01.

TABLE 8 Direct effect, indirect effect, and total effect between latent variables

		<i>Y_p</i>	<i>Y_c</i>	<i>Y_g</i>
<i>Y_p</i>	Direct effect	0	1.102	0.199
	Indirect effect	0	0	0.216
	Total effect	0	1.102	0.416
<i>Y_c</i>	Direct effect	0	0	0.196
	Indirect effect	0	0	0
	Total effect	0	0	0.196
<i>Y_g</i>	Direct effect	0	0	0
	Indirect effect	0	0	0
	Total effect	0	0	0

degree of path. Community resilience (*Y_c*) and government resilience (*Y_g*) had a significant positive impact on public safety resilience (*Y*). The path coefficient from *Y_c* to *Y* was greater than that from *Y_g* to *Y*, which indicated that community resilience had a greater impact on public safety resilience than personal resilience and government resilience did. As for the path relationship among personal resilience, community resilience, and government resilience, the path coefficient from *Y_c* to *Y_p* was 1.102, the path coefficient from *Y_g* to *Y_p* was 0.199, and the path coefficient from *Y_g* to *Y_c* was 0.196, indicating that community resilience had a positive effect on personal resilience and government resilience on personal and community resilience.

We further explored the direct, indirect, and total effects among *Y_p*, *Y_c*, and *Y_g*. Table 8 showed the output results of SEM. The direct effect value of government resilience on personal resilience was 0.199. The effect value of government resilience indirectly affecting personal resilience through community resilience was 0.216. Therefore, the total effect of government resilience on personal resilience was 0.416.

Next, we analyzed the relationship between the latent variables and their corresponding observed variables to test the hypothesis *H₄*, as shown in Table 9.

According to the calculation results, at the significance level of *p* < 0.01, each observed variable of the three different

levels was significantly related to its corresponding resilience. The details are as follows.

- At the personal level, *X₁₂* (Knowledge and skill) and *X₁₃* (Safety consciousness) had a higher positive impact on personal resilience. It showed that Beihang community residents thought that the improvement of personal resilience during the pandemic required the public to learn scientific methods to deal with the pandemic and have good health habits.
- At the community level, community resilience was positively influenced more by *X₃₄* (financial ability) and *X₃₃* (organization and institution) related to inherent ability, *X₄₂* (materials management), *X₄₃* (funds management), and *X₄₄* (public opinion management) related to operational ability, and *X₅₁* (improvement of materials and facilities) related to improvement ability. This showed that the key to dealing with the epidemic included more investment, professional protective equipment, and medical facilities, and better organization and management abilities in the community (management of foreign population, susceptible population, and infected population, etc.).
- At the government level, all observed variables had a high positive effect on government resilience. This showed that during the epidemic, the government would effectively improve its ability to deal with the pandemic as long as it

TABLE 9 Estimation of model path coefficient

			Coefficient	SE	Critical ration	<i>p</i>	Effect
X_{11}	←-	Yp	-0.085	0.080	-5.058	***	-
X_{12}	←-	Yp	0.697	0.046	13.649	***	+
X_{13}	←-	Yp	0.736	0.041	13.765	***	+
X_{21}	←-	Yp	0.490	0.049	13.539	***	+
X_{22}	←-	Yp	0.553				+
X_{31}	←-	Yc	-0.085				+
X_{32}	←-	Yc	0.051	0.866	3.609	***	+
X_{33}	←-	Yc	0.777	1.143	3.599	***	+
X_{34}	←-	Yc	0.844	0.379	3.330	***	+
X_{41}	←-	Yc	0.274	1.006	3.598	***	+
X_{42}	←-	Yc	0.843	1.276	3.600	***	+
X_{43}	←-	Yc	0.863	1.370	3.598	***	+
X_{44}	←-	Yc	0.855	1.273	3.602	***	+
X_{51}	←-	Yc	0.898	0.511	3.456	***	+
X_{52}	←-	Yc	0.366	0.510	3.476	***	+
X_{53}	←-	Yc	0.392	0.649	3.520	***	+
X_{61}	←-	Yg	0.904				+
X_{62}	←-	Yg	0.954	0.020	51.926	***	+
X_{71}	←-	Yg	0.917	0.030	36.868	***	+
X_{72}	←-	Yg	0.848	0.025	38.711	***	+
C_1	←-	Y	0.217				+
C_2	←-	Y	0.922	0.480	5.217	***	+

*** Means relationships are significant at p -value < 0.001.

can take positive measures, whether they were about command and decision making or helping the community.

- In addition, it can be seen that the recovery (C_2) had a greater effect on the public safety resilience Y than the resistance (C_1) did.

4.3 | Principal component regression analysis

First, Kaiser-Meyer-Olkin (KMO) and Bartlett's sphere test were performed on the original variables. The KMO test coefficient was 0.864, and the Bartlett sphere test results showed a p -value < 0.001. According to the KMO measurement standard given by Kaiser, the original variables were suitable for factor analysis (Kaiser & Rice, 1974).

The results of orthogonal rotation of the factor loading matrix by using the maximum variance method were shown in Table 10. It can be seen that the first factor f_1 mainly described the community operation ability and the material facilities and organizational structure in the inherent ability. The second factor f_2 mainly described the improvement ability in community resilience, and the third factor f_3 mainly described the population and economic ability in the inherent ability of the community.

TABLE 10 Rotated factor loading matrix

	Factors		
	1	2	3
X_{31}	-0.054	0.004	0.961
X_{32}	0.826	0.177	0.018
X_{33}	0.885	0.154	-0.037
X_{34}	0.237	0.254	0.309
X_{41}	0.845	0.170	0.122
X_{42}	0.906	0.143	0.051
X_{43}	0.878	0.174	0.047
X_{44}	0.870	0.207	0.041
X_{51}	0.146	0.925	0.071
X_{52}	0.161	0.953	0.053
X_{53}	0.260	0.883	0.033

Next, we used resistance (C_1) and recovery (C_2) as dependent variables, and the three factors f_1 , f_2 , and f_3 obtained by principal component analysis as independent variables for regression analysis. Stepwise regression was used to get the regression results, which were shown in Tables 11 and 12.

The regression equation of resistance was: $C_1 = 0.182f_1 + 2.915$.

TABLE 11 Regression results of resistance ability

	Non standardized coefficient		Standardized coefficient		
	<i>B</i>	<i>SE</i>	<i>Beta</i>	<i>t</i>	<i>p</i> -Value
(Constant)	2.915	0.033		87.914	.000
f_1	0.193	0.033	0.182	5.819	.000

Note: Dependent variable: C_1 .

TABLE 12 Regression results of recovery ability

	Non standardized coefficient		Standardized coefficient		
	<i>B</i>	<i>SE</i>	<i>Beta</i>	<i>t</i>	<i>p</i> -Value
(Constant)	4.589	0.015		304.260	.000
f_1	0.400	0.015	0.630	26.482	.000
f_2	0.130	0.015	0.205	8.629	.000

Note: Dependent variable: C_2 .

The regression equation of recovery was: $C_2 = 0.630f_1 + 0.205f_2 + 4.589$.

The results of regression model showed that, at a significance level less than 0.001, f_1 , which mainly described the operation ability of the community and the variables such as material facilities and organizations in the inherent ability, had the greatest impact on the resistance ability. Compared with the resistance ability, the recovery ability was significantly influenced by both f_1 and f_2 , which mainly characterized the community improvement ability.

4.4 | Discussion

Based on the full analysis of the questionnaire data, this section verifies the hypotheses proposed in the study according to the calculation results of the SEM and regression analysis.

(1) Hypothesis 1 addresses the positive effect of community resilience on personal resilience. People are one of the important components of the community, and their activities are directly affected by the community. In this paper, the public safety resilience index reflects that community resilience includes personal resilience. In Figure 5, there is also a correlation between the residuals of individual economic and social characteristics and community demographic characteristics.

According to Table 7, the path coefficient from Y_c to Y_p is 1.102, which indicates that during the epidemic period in the Beihang community, through the improvement of community resilience, personal resilience would also be improved. Therefore, hypothesis 1 could be partially supported. Resilience theory has been proven to help people develop effective strategies to deal with disasters (Gowlland et al., 2009), and the improvement of personal coping ability is an important measure to improve community resilience (Funk et al., 2010). In practice, Ambelu et al. (2017) proposed measures to improve the ability of herdsmen to recover from

disasters by improving community resilience (Ambelu et al., 2017). Therefore, the results of this study are consistent with the those of previous studies. Emphasizing the relationship between people and community is of great significance for improving personal and community resilience.

(2) Hypothesis 2 assumes that government resilience has positive effects on community resilience and personal resilience. According to Tables 7 and 8, government resilience can play a positive role in both community resilience and personal resilience. Meanwhile, government can indirectly affect personal resilience by influencing community resilience. These findings support Hypothesis 2. Compared with people and the community, the government has a greater resource management and scheduling ability (United Nations, 2005). In this epidemic, the Chinese government has significantly enhanced the resilience level of the community and people by allocating and dispatching professional protective materials and equipment, medical staff, and funds among different communities. In addition, there is research showing that governments can also prevent and control the spread of infectious diseases among the public through the collection, sorting, and distribution of various kinds of information through social media (Eke, 2011).

(3) Hypothesis 3 is that community resilience is the factor that has the greatest impact on public safety resilience. In Table 7, improving the resilience at the community and government levels respectively could promote the improvement of the overall public safety resilience level, especially at the community level. Therefore, Hypothesis 3 could be verified. The community plays a critical role in responding to public emergencies (Leykin et al., 2016). Community prevention and control are at the core position of the prevention and control work, and interrupting the community spread is considered an important means to control the large-scale outbreak of the COVID-19 epidemic (World Health Organization, 2020a). Community resilience is directly affected by government behavior, and community behavior also directly

affects the personal resilience. Therefore, increasingly more researchers study resilience at the community level at present (Bastaminia et al., 2017; Niskanen, 2018). Since the history, geography, infrastructure, population, and economic conditions of different communities are unique, each community should develop its own resilience plan and a resilience construction mechanism involving the entire community (Cutter et al., 2014; Norris et al., 2008).

(4) Hypothesis 4 is that the factors related to professional protective materials and facilities have a relatively large impact on public safety resilience because of the specificity of COVID-19. According to Table 9 and Figure 5, materials and facilities played very important roles in improving the public safety resilience of the Beihang community, which was very consistent with the actual situations of emergency masks, protective clothing, respirators, and various drugs in various regions during the epidemic period (Corsini et al., 2021). Therefore, improving the purchase, storage, and management abilities of various professional protective equipment and medicines would greatly improve the level of public safety resilience and the sense of public health safety. According to the analysis results, Hypothesis 4 could be verified.

In the process of testing Hypothesis 4, we found an unexpected interesting phenomenon: Beihang community residents had a high concern for community public opinion management and government public opinion guidance. For example, in the factors related to the community operational ability, the community management of public opinion was more important than material management. Due to the confidence in the national industrial production ability and organizational ability, the residents of the Beihang community were not so worried about material shortages. However, the network information on various kinds of social software and self-media made the public more anxious and uneasy during the epidemic, especially the false information caused unnecessary panic in the public (van Stekelenburg et al., 2021); therefore, community residents paid more attention to the intervention and guidance of public opinion. This phenomenon was also common in other countries in the world. Nazir and Satici respectively studied the impact of the spread of social media networks in Palestine and Turkey on the public during the epidemic (Nazir et al., 2020; Satici et al., 2020).

(5) Hypothesis 5 supposes that resistance is more affected by the inherent ability of the community. According to the results of regression analysis, during the epidemic, the resistance ability in public safety resilience was related to f_1 , which describes the variables of community operation ability and inherent ability of the materials, facilities, and organizations, while its relationship with other variables was not obvious. Based on the data analysis, Hypothesis 5 was not fully verified. According to the calculation results, the community should pay more attention to materials, equipment and community organization, which is consistent with the conclusion of other studies that strengthen the infrastructure, materials, and equipment and organization to improve the community

ability (Cutter et al., 2010; Norris et al., 2008; Qasim et al., 2016).

(6) Hypothesis 6 assumes that recovery is more affected by the community operational and improvement abilities. The recovery here was used to indicate whether the Beihang community can recover as soon as possible from the impact of the epidemic and to what extent. According to the results of the regression model, in addition to f_1, f_2 , which mainly describes the community improvement ability, also had an important impact on the resilience, so Hypothesis 6 was verified. Recovery ability is also an important part of resilience research (Ainuddin & Routray, 2012). The organization, mobilization, and learning ability of community residents and managers are of great significance to the resilience construction of the community.

To sum up, the theoretical framework and basic hypotheses proposed in this study could be basically supported by the data collected by the questionnaire. Although this study has conducted many quantitative analyses to assess the public safety resilience during the epidemic comprehensively, it still has some limitations. First of all, this study only collected relevant data on a certain community in Beijing, China. Therefore, the results of the quantitative analyses can only reflect the public's perception of public safety and resilience in this area. However, these conclusions still have some value for the government, public health managers and scholars who want to deepen their understanding of public safety and conduct research on a larger scale, especially when the COVID-19 pandemic has become a global public safety incident and more knowledge of how to effectively react to it is needed. Secondly, the three public safety level measurements (before, during and after the epidemic) in this study were collected through a questionnaire at the same time, after the hard moment of the epidemic and when the public perception of safety was recovering, so there was a deviation from the actual situation, but it can still reflect the change of public perception of public safety under the epidemic to a certain extent. Finally, this paper proposes to analyze the public safety resilience from the three levels of person, community, and government. However, due to the particularity of the case study, the direction of the interactions among the three levels cannot be fully verified, and it is necessary to design more targeted methods to reveal the internal relationship among them in the future study.

5 | CONCLUSION

The purpose of this study is to define and measure the components and factors that affect the public safety resilience during public emergencies. Aiming at applying resilience theory in the field of public safety, this paper gives a definition of public safety resilience and establishes a complete conceptual framework and index system on the three levels of the individual, community, and government. It uses the concepts and mathematical formulas of resistance and recovery to represent the dynamic characteristics of the public safety

resilience. To assess public safety during the COVID-19 outbreak, the empirical study attempted to use resilience theory to help academia and the government to identify the main factors affecting the prevention and control of the epidemic. Based on the establishment of an empirical model and the corresponding assumptions, this study collected the relevant data on the community public health status and the influencing factors of public safety resilience using questionnaires distributed to the Beihang community in Beijing. All the hypotheses were tested, and the relevant factors affecting the public safety resilience of the Beihang community during the epidemic situation were discussed. Finally, the limitations of this study were summarized and refined, and the possible future research directions were pointed out.

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