Research Paper

Health-oriented Resilience Evaluation of Village-amid-the-city in Cold Area:A Case study of Harbin, northeastern China

Tingting YU, Harbin Institute of Technology, Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, China

Xu Guo, Harbin Institute of Technology, Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, China

Abstract

According to WHO statistics, from the perspective of global health coverage, villages-amid-the-city, as a special form of urban settlement, are lagging behind in terms of population health and environmental development. Under the impact of the New Crown Epidemic, the ability of community-based settlements to cope with public health events highlights their importance in dealing with health risks. Reducing the health risks of vulnerable groups has become an urgent shortcoming that needs to be filled in order to promote universal health coverage. In order to better understand the level of health-oriented resilience in villages-amid-the-city, a specific framework for analyzing health-oriented resilience indicators in villages-amid-the-city is proposed to reflect the health-oriented resilience drivers affecting villages-amid-the-city and to propose corresponding updated coping strategies to cope with public health risks and to shape livable villages-amid-the-city as places to live. This study takes a typical villages-amid-the-city in Harbin City, Heilongjiang Province, as the research object. Taking the DPSIR model as the theoretical basis and pressure, motivation, state, reaction and impact as the evaluation dimensions of health-oriented resilience, the health-oriented resilience evaluation indexes of villages-amid-the-city are constructed, the health-oriented resilience of six typical villages is calculated by using the composite index method, and the driving factors of the health-oriented resilience of villages-amid-the-city are explored by combining the factor analysis and principal component analysis. In addition, the framework will propose an updated approach for planning decision makers on reducing health risks in villages-amid-the-city. Thus, its policies and practices aimed at improving the environment of cold villages-amid-the-city settlements can be targeted as a tool for implementation.

Keywords

Health-oriented resilience, village-amid-the-city, frame, AHP-BP

1. Introduction

In recent years, global urban public health has been undergoing recovery and reshaping as the shock of the new Crown Pneumonia epidemic came to an end. However, the Global Monitoring Report on Universal Health Coverage 2023 warns that billions of people around the globe are seriously lagging behind on the path to universal health coverage, and that the challenges to global health remain enormous . Inequalities within and between countries persist, with vulnerable groups having lower access to health and related services, facing higher health risks and higher associated mortality rates (Acuti et al., 2020). This is further illustrated by the COVID-19 pandemic, which unevenly affects vulnerable groups versus poorer areas, such as migrants (Alnusairat et al., 2023), ethnic minorities, older people, or those living in deprived neighbourhoods. Villages-amid-the-city, as lagging areas of urban planning, are areas where urban low-income populations are concentrated, but there are a series of problems that threaten the health of human habitats, such as the lack of public services, high security risks (Champlin et al., 2023), and dirty and unkempt environments, which greatly limit the integration of villages-amid-the-city into the development process of globally healthy cities (Mahmood et al., 2022). Health-oriented resilience assessment can provide support for the preparation and defence of villages-amid-the-city before the occurrence of health hazards (Nurmala et al., 2023), response and resistance during the occurrence of health hazards, and self-adaptation and repair after the occurrence of health hazards (Castleden et al, , 2011), and it is an important path to make up for the shortcomings of urban health construction and a necessary link to help the sustainable development of the city, but the relevant research has not yet been carried out widely (Wang et al., 2021).

Health-oriented resilience is the ability to remain healthy in the face of health risks (Panter-Brick 2014). Resilience plays a key role in supporting sustainable lifestyles and promoting health and well-being. Reducing individual behavioural risk factors and improving health-care services are part of improving health-oriented resilience and more critically, addressing human settlements, including buildings, roads, parks, spaces and all other elements constructed or transformed by urban planners (Liu& Jia, 2021). These elements influence the living conditions of residents, the quality of their homes and the community environments in which people interact, and it is these physical and social living conditions that lead to individual behavioural risks (Zhang et al., 2023). In recent years, therefore, building the resilience of human settlements has become an emerging approach to public health emergency preparedness and response, encompassing both individual preparedness and the creation of supportive social environments within living environments to withstand and recover from disasters (Li et al., 2023). Resilient living environments can provide adaptive means of coping with public health risks, thus providing effective safeguards for healthy living.

Research on health-oriented resilience in villages-amid-the-city has three distinct advantages for improving lagging residential environments that host public health. Firstly, the relationship between environmental problems and human health in villages-amid-the-city is analysed using human behaviour as a mediator, and correlates of health-oriented resilience are identified (Jamroni et al., 2021). Second, it examines how to quantitatively evaluate health-oriented resilience in villages-amid-the-city and how to scientifically analyse the drivers (Tan et al., 2021). The third advantage is that renewal strategies for villages-amid-the-city can be proposed based on the health-oriented resilience evaluation (Therrien et al., 2015), and the construction of livable villages can be promoted through appropriate planning and management (Zeng et al., 2022).

In view of this, this study proposes a conceptual framework of health-oriented resilience in villages-amid-the-city from the perspective of health-environmental resilience of villages-amid-the-cityrs. The spatial characteristics of six typical villages-amid-the-city in Harbin City are identified based on field

research, and the health-oriented resilience evaluation model is used to analyse the problems and driving mechanisms, providing theoretical support for choosing the optimal villages-amid-the-city route to promote a livable environment. The objectives of this study are as follows:

(1) This paper will propose a health-oriented villages-amid-the-city resilience evaluation research framework that contains research steps for quantitatively and comprehensively exploring the derivation of resilience indicators for cold villages-amid-the-city.

(2) This paper analyses the interactive mechanism of health-oriented villages-amid-the-city resilience, and constructs an evaluation index system and evaluation method. On this basis, the health-oriented resilience composite index of 12 typical villages-amid-the-city is calculated to further explore the construction of different types of villages-amid-the-city.

(3) This study will propose health-oriented resilience planning strategies and policies for villages-amid-the-city with health dimensions in a hierarchical and categorised manner, which will serve as a reference for health-oriented resilience enhancement of villages-amid-the-city in cold regions.

2. Methods

Through a literature review of Scopus, we provide examples of health-oriented resilience (HR) definitions and focus on methods that assess vulnerability thresholds or give results that can be used for ranking.

2. 1. Definitions of Health-oriented Resilience

When we look at the health-oriented resilience literature in Scopus, there are over hits for the term ‘health-oriented resilience’ in >30 years of publication history. In the last years, there has been an increasing focus on resilience for different health of threats, such as extreme climate events or public health event. In order to distinguish between these concepts, some definitions are presented in Table 1.

Table 1. Several examples of definitions. Source: Review.

Dimensional	Characteristics	Brief description of concept	Author
Special sense dimens-ional	Resilience of public health systems	Physiological and psychological states that arise in complex social contexts combine to determine human adaptive capacity in the face of adversity, change or major risks.	Wulff, K. , 2015
		The resilience of a health system is its ability to absorb, adapt and transform in the face of shocks such as epidemics, natural disasters or major social conflicts, while at the same time requiring that the system maintains its original structures and	Martinez, L. , 2020
General sense dimens-ional	The multidim-ensional resilien-ce of gove-rnance, space,	Resilience is considered a dynamic process of adaptation. It is related to processes and capabilities at the ind-ividual, community and system level	Oke, A. E. , 2020 Cheshmehzan

	society and economy with public health as the core.	that result in good health and social outcomes	gi, A. , 2020.

2.2 Data

Harbin is a typical representative of the cold area cities in Northeast China, so it is selected as the research object in this paper.At present, Harbin, as a mega-city, contains a total of 77 villages-amid-the-city in the urban area, involving a land area of 184 square kilometres. However, the relatively poor location and low development potential of Harbin's villages-amid-the-city have made the process of renewal and transformation relatively slow, and problems such as lack of facilities and environmental remediation have become more prominent, posing a threat to the health of the residents of the cold villages-amid-the-city.

In order to ensure the representativeness of the study, six villages-amid-the-city distributed in four different administrative districts were selected for this study, which are as follows:Friendship Village\Deng Jia Village\Hada Village\Fu Shan Village\Hongwei Village and Dong Ming Village (Table 2).

The data used in the research model are mainly from urban geographic data, including Harbin Statistical Yearbook, Harbin Regional Statistical Bulletin, and Harbin Regional Environmental Condition Bulletin. It also contains some meteorological data, which comes from the China Air Quality Online Monitoring and Analysis Platform (https: //www. aqi research. cn/) website.

Table 2. Several examples of definitions. (source: self-drawn by the author)

Friendship Village	Deng Jia Village	Fu Shan Village
		
Hongwei Village	Hada Village	Dong Ming Village

2. 3 Theoretical Basis of Health-oriented Resilience Evaluation

Based on the literature review of existing empirical studies, this paper summarises four types of theoretical frameworks(Table 3) for resilience assessment that are currently frequently used in the field of urban resilience research as categorical dimensions for indicator screening.

Table 3. Four types of theoretical frameworks for resilience assessment. (source: self-drawn by the author)

Urban Resilience Assessment Models	Model Features
PSR Model	It allows for the integration of urban disaster resilience and response processes. The division of this process into stress, state and response corresponds exactly to the three resilience processes of disaster resistance, disaster absorption and system recovery(Das et al., 2020).
PEOPLES Model	Different quantitative evaluation indicators were used to evaluate the resilience of the system in terms of seven dimensions: population, environmental and ecological governmental organisation, physical infrastructure, lifestyle and community management, economic development, and social and cultural capital, Evaluate community-wide resilience in terms of three dimensions: recovery time, function and strength(Cimellaro et al., 2016)
CRAM Model	A five-dimensional model (21 items) has been developed through statistical and cluster analysis of relevant indicators of the economic, social and building infrastructure of the current community to obtain the gap between the recovery time of the current facilities and the expected design recovery time, which allows for the resilience evaluation of the current community(Mukhopadhyay et al., 2019).

DPSIR Model	The DPSIR model is a conceptual model of a widely used system of evaluation indicators in environmental systems, developed as a system of indicators for measuring the environment and sustainable development, which looks at human-environmental system interactions from a systems analysis perspective. The model divides the evaluation indicators that characterise a natural system into five modules: Driving forces, Pressure, State, Impact and Responses. (Mukhopadhyay et al., 2019)

3. Results and Discussion

3. 1. Index Screening

We summarized and reviewed the past empirical literature through a process that involved rigorous literature search, screening and extraction. In this paper, journal articles published between January 2015 and March 2023 were searched in three databases, including Medline, Web of Science and CNKI.

3. 2. Construction of Assessment Framework

The DPSIR model(Figure 1) is a conceptual model for the evaluation of indicator systems, which was developed in 1993 by the European Environment Agency through a modification of the PSR model. The basic meaning of the model is: system driving force (Driving) leads to pressure (Pressure), the pressure forces the system to change certain state (State), Changes in state have effects on the system, and these effects cause humans to react (Response) either directly or indirectly.

It is enduring resilience oriented towards physical health promotion, which focuses not only on the outcomes of resilience at work (i.e., absorptive, adaptive and transformative capacities), but also requires governance capacities at the community or village level to respond to emergencies. These operational dimensions are interrelated and together characterize resilience management in health-oriented resilience.

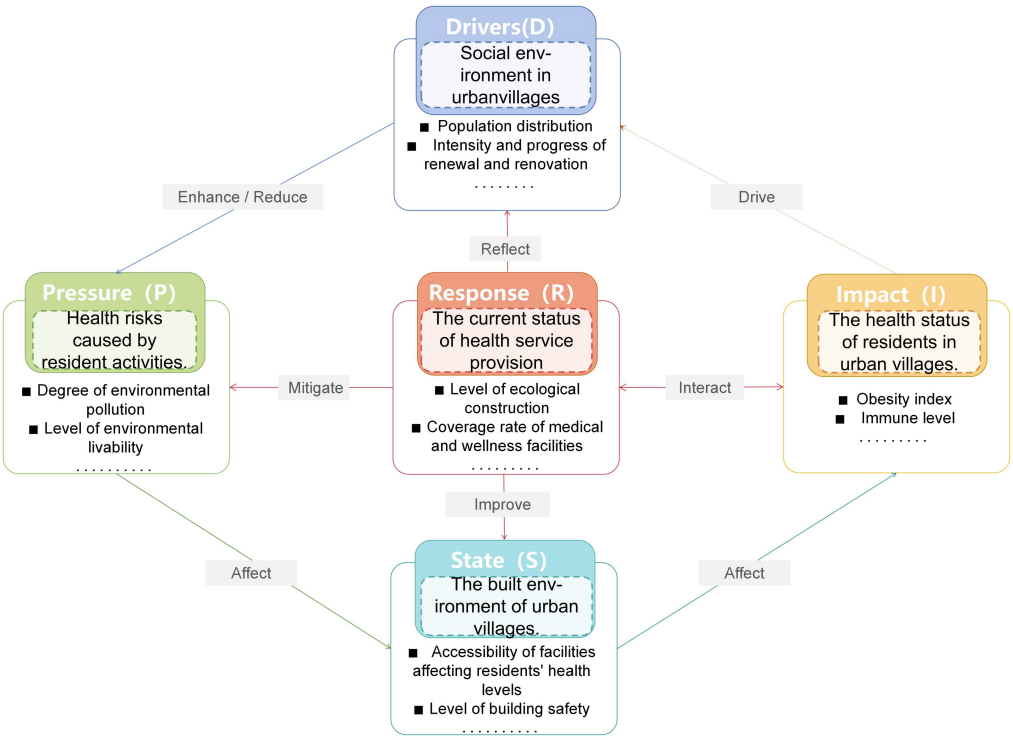

Figure 1. The DPSIR model. (source: self-drawn by the author)

"Response (R)" is organized into five dimensions. It is extended and optimized based on the PSR and DSR models, and can be analyzed from the dimension of the whole system with the intrinsic connection between activity, economic, social and environmental factors. In this study, the DPSIR model was introduced to assess the resilience of community habitat. The model uses five levels and 12 indicators (Table 4). In the model constructed in this paper, drivers (D) exert pressure (P) on the environment, leading to changes in the state of the environment (S). This further affects human activities and health (I). Villages-amid-the-city 's environments can respond to the feedback of drivers and pressure (R) through measures such as renewal, and Figure 1 represents the DPSIR model of the CR assessment system. The DPSIR model represents:"Driving forces (D)", "Pressure (P)", "State (S)", "Impact (I)", tates, and impacts (R) to promote healthy villages-amid-the-city development.

Based on the content of previous studies and empirical cases, this study screened to identify key indicators adapted to urban villages in each level of criteria.

Drivers (D) are the elements that drive dynamic change in the environmental regeneration and improvement of villages-amid-the-city. Selected indicators include population vulnerability, density of population, density of building, income level. They refect built environmrnt, population. These drivers influence stressors, state factors, and response factors, and affect the physical activity and health-related lifestyle habits of the population.

Pressure (P) refers to factors that have an inhibiting effect on maintaining or restoring the health status of residents in villages-amid-the-city. They include indicators that reflect environmental pressure and pollution such as CO2 emissions, PM2. They reflect the environmental pressure and pollution of pollution

faced by the urban village. They affect state and response factors and influence residents' outdoor activities.

State (S) represents the current condition of the environment that is subject to drivers and pressures that can be used for physical activity by urban village residents. Indicators such as the density of roads, bus stops and subways, coverage of convenient commercial services, and land use structure reflect the state of the environment and typical problems in urban villages. These factors are influenced by drivers and pressures, and also influence other factors and responses. For example, road density may lead to congestion and traffic problems. This would be detrimental to residents' outward mobility..

Impact (I) refers to the results of various types of environmental factors in villages-amid-the-city that act on human health activities. For example, indicators such as residents' fitness awareness and occupational health risks reflect the status of physical activity resources in the village. These indicators directly affect residents' health activities. This is because more connected roads and more sports facilities will provide more exercise opportunities for residents in villages-amid-the-city.

Response (R) indicators are behavioral feedback given by urban village residents to the natural, built and social environments. Indicators such as green space density, health insurance coverage and quality of volunteer service refect residents'responses and preferences related to health activities. And the following indicators (Table 4) were finally obtained from the literature review.

Table 4. The evaluation index of health-oriented resilience. (source: self-drawn by the author)

Criterion layer	Index layer	Description of indicators
Drivers (D)	D1 Population vulnerability	Proportion of children under 7 years of age and elderly people over 65years of age
	D2 Density of population	The statisticians from the Haerbin Statistical Yearbook
	D3 Density of building	Sum of base area of buildings in villages-amid-the-city/construction land area of villages-amid-the-city
Pressure (P)	P1 Number of refuse collection points	Field research statistics
	P2 AQI	The statisticians from the China Air Quality Online Monitoring
State (S)	S1 Density of food places	Distribution density of catering facilities in villages-amid-the-city
	S2 Density of convenient commercial services	Distribution density of commercial facilities in villages-amid-the-city
Impact (I)	I1 Residents fitness awareness	Resident self-assessment questionnaire
	I2 Per capita sports area	Field research statistics
Response (R)	R1 Green density	Green space area/total villages-amid-the-city site area
	R2 Health insurance coverage	Resident self-assessment questionnaire

3. 3. Data analysis model

In this paper, the AHP-BP method is used to calculate each health-oriented elasticity index factor. This method effectively avoids the shortcomings of the hierarchical analysis method, which is highly subjective. At the same time, the neural network works by simulating the human brain, which can learn autonomously like human beings and has functions such as nonlinear transformation, which can effectively exclude randomness and subjectivity, and is an innovation to the traditional evaluation method. The AHP-BP model is as follows (Figure 2).

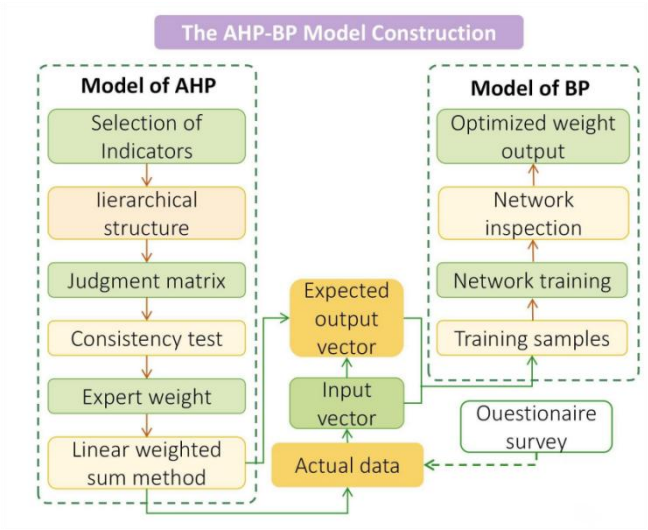

Figure2. The AHP-BP model. (source: self-drawn by the author)

3. 4. The Calculation of Health-oriented Resilience

EpiData 3. 0 software was used to enter the data and establish the database. SPSS 21. 0 software was used to analyse the data, describing the health-oriented resilience level of each dimension of health-oriented resilience in each villages-amid-the-city with mean and standard deviation, and Matlab software to construct the BP neural network model and calculate the evaluation value.

Firstly, the villages-amid-the-city health evaluation index system is analysed at each level based on analytic horizontal process. Then repeatedly train the network to make it have associative memory and prediction ability. The topology of BP neural network is shown in Figure 3[i], the basic idea is to adjust the weights and thresholds of the network to minimise the sum of squares of the errors of the network's output layer, so that the output value is as close as possible to the target value, the specific process is as follows.

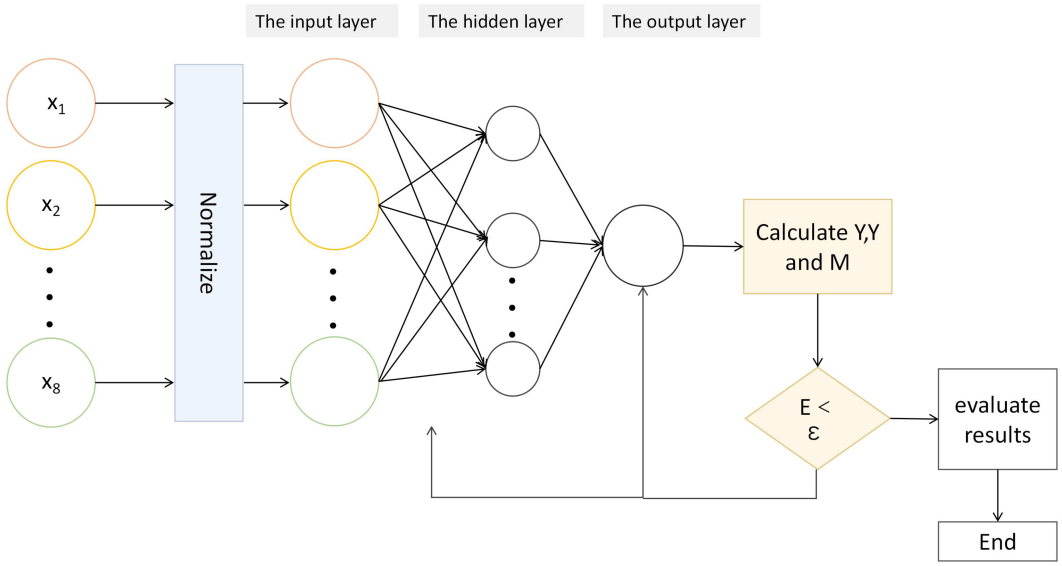

Figure3. BP neural network topology diagram.

(i) Initialise the weights and thresholds of the network. Use ω_{ij} to denote the connection weights from the input layer to the implicit layer, ω_{jk} to denote the weights from the implicit layer to the output layer, θ_i to denote the implicit layer threshold, and θ_k to denote the output layer threshold.

(ii) Input learning samples, calculate the output value of each layer. X_i represents learning samples, i=1, 2, ... , n, n is the number of input layers. z_j represents the output value of each node of the implicit layer, f is the implicit layer excitation function, and the function chosen in this paper is f(x)=1/[1+e^(-x)], which is calculated as follows:

$$z_j = \int\left(\sum_{i=1}^{n}\omega_{ij}x_i - \theta_j\right), j = 1,2,\cdots,l \ (l \text{ is the number of implicit layer nodes})$$

Y_k denotes the output layer node output value, which is calculated as follows:

$$Y_k = \sum_{j=1}^{l}\omega_{jk}z_j - \theta_k, k = 1,2\cdots,l \ (\ l \text{ is the number of output layer nodes})$$

In this case, the formula for calculating the number of nodes in the implicit layer is $l<\sqrt{(m+n)}+a$ (m is the number of output nodes, n is the number of input nodes, and a is a constant between 0 and 10). In this study, 11 indicators were used as input layers. The comprehensive evaluation of health-oriented resilience of villages-amid-the-city is used as the output layer, therefore, the input node is 11, the output node is 1, and the range of values of the neurons in the implicit layer is calculated according to the above implicit layer calculation formula as [6-16], after continuous attempts, it was determined that the number of neurons in the hidden layer was taken as 10 this time by the trial-and-error method.

(iii) Thresholds are updated by calculating relative errors and correction weights.

According to the learning continuously calculate the error MSE, and compare with the expected error accuracy, if the actual calculated error is within the acceptable range, then the learning is finished, otherwise return to step (ii) to adjust the neuron and threshold according to the rules for further learning,

until it meets the specified error, accuracy, or number of training times. Simulate the neural network model by training samples, and input 6 sample villages-amid-the-city data into the simulated network model to verify the simulation (Table 5).

Table 5. The health-oriented resilience level of 6 sample villages-amid-the-city.

Health-oriented Resilience Level	Village-amid-the-city	Score	Description of resilience Level
Very Low	Deng Jia village	7. 45	flat terrain, good ecological environ-ment, rare facilities, complete culture, poor economy,dilapidated buildings
Low	Dong Ming village	7. 89	Certain ecological resource,and transformation, generic building landscape, faint buildings
Moderate	Hong Wei village	8. 37	incomplete environment and building transformation, low vitality, simple industry structure,incomplete facilities
High	Fu Shan village	8. 72	adequate infrastructure and environmental improvement, lost custom culture, poor agricultural economy,strong construction,
Serious	Ha Da village	9. 13	complete facilities and environmental improvement, damaged buildings, diversity product and affluent life,diverse culture
	Friendship village	9. 26	

3. 5 Discussion

The villages-amid-the-city in Harbin have relatively large differences in their health-oriented resilience due to their different demographics, development levels, and built environment conditions. By studying the resilience characteristics of six typical villages-amid-the-city in Harbin, this paper finds that the following characteristics exist in the health-oriented resilience of three types of typical villages-amid-the-city:

Ha Da village and Friendship village have a low density of buildings, a high level of health awareness among the residents, and the villages reflect a correspondingly high level of health. There are relatively few refuse sites and low levels of greenery in Deng Jia village and Dong Ming village, with a high level of coverage of food and drink establishments. Correspondingly, the two villages have relatively low levels of health-oriented resilience on the ground. The level of health-oriented resilience in the Hong Wei village is moderate, with no significantly relevant indicators of health-oriented resilience.

Due to social differentiation, villages-amid-the-city are vastly different from traditional settlements in terms of composition, employment structure, and social relationships, and the level of health resilience in villages-amid-the-city has become a key aspect that needs to be improved in order to cope with public health risks. UN-Habitat reminds that although population density does not directly affect the spread of epidemics, this study finds that overcrowded housing, insufficient living services, and lack of open space in villages-amid-the-city not only reduce health resilience, but also reflect serious health equity conflicts, which is a key target for the renewal of villages-amid-the-city at present.

4. Conclusion

Increased levels of health resilience in urban villages are key to advancing sustainable urban spatial environments in all countries, as well as an effective guarantee of global health equity. The impact of urban village living environments on residents' health has increasingly become a common focus of urban planning, geography and preventive medicine research. Only by clarifying the more core health resilience indicators in urban village living environments can we more accurately provide effective and sustainable coping strategies for the renewal of healthy urban villages. In this paper, we investigated the health resilience characteristics of different urban villages under special climatic backgrounds using six typical urban villages in China's severe cold regions as test sites, and revealed the characteristics of the built environments of urban villages with different levels of health resilience. This can provide a reference for future urban villages to implement regeneration actions with health as the goal.

However, the number of subjects in this study is limited, and it is only of high reference significance for urban village regeneration under severe cold climate. The applicability of this study to urban villages in other climates needs to be further explored.In addition, the study showed that the level of health resilience in urban villages was not significantly related to the number of waste stations in the environment, which is different from the findings of previous studies(Wilson et al., 2018) and requires further empirical evidence.

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