

Research on the health performance improvement strategy of traditional dwellings in southern Henan province under the concept of healthy building

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Abstract: As the most basic unit of human life, the health attributes of dwellings have a significant impact on residents' health. Rural areas in Henan Province exhibit a high degree of "hollowing out," with permanent residents being highly sensitive to health issues. Therefore, studying the improvement strategies for the health performance of rural dwellings is of great significance to residents' health. This paper reviews the development of domestic healthy building concepts and relevant evaluation systems, and analyzes the correlation and mechanism between various building element indicators and health issues in dwellings based on relevant evaluation systems. Finally, drawing on modern healthy building concepts, the paper conducts a health performance analysis of traditional dwellings in southern Henan Province from four aspects: thermal environment, light environment, air quality, and sound environment, and proposes targeted improvement strategies.

Keywords: Healthy buildings; Southern Henan; Traditional dwellings; Health performance

Introduction: Against the backdrop of the "Healthy China" strategy, the construction industry has significantly increased its focus on residential safety, health, environmental protection, and multifunctionality, with healthy buildings becoming a trend and direction of development [1]. As early as the Qing Dynasty official records, Xinyang was referred to as southern Henan [2], a concept still referenced in this article. The unique geographical environment and climate conditions of southern Henan have nurtured a brilliant architectural culture, giving rise to a diverse range of residential building types [3]. However, Henan Province, as a major agricultural and population-transferring province, exhibits a prominent phenomenon of rural "hollowing out" [4]. On one hand, the contradiction between traditional dwellings and modern living and production methods in terms of health performance is becoming increasingly prominent. On the other hand, the left-behind population mainly consists of the elderly and children, who are highly sensitive to health issues but have relatively low subjective awareness of health and safety. Based on this, by analyzing the interaction mechanism between the building element indicators of traditional dwellings in southern Henan and health performance issues, targeted strategies for improving the health performance of dwellings are proposed, which have important guiding significance.

1 Association between Resident Health and Healthy Attributes of Residential Buildings

1.1 Correlation between Residential Building Performance and Resident Health

Residential dwellings constitute the most fundamental units of human habitation, and their health attributes are crucial for overall human health. Humans spend approximately 80% of their time indoors [5]. The formation of human diseases primarily stems from the interaction between the human body and the external environment; thus, the health performance of buildings directly influences human health. Previous studies have indicated [6-8] that factors such as spatial layout, floor plan arrangement, material properties, and form factor indicators of buildings directly impact indoor air quality, thermal and humidity conditions, sound environment, light environment, and other indicators, thereby affecting human health levels. Therefore, by optimizing the architectural performance of traditional dwellings, creating a healthy living environment can reduce the risk of residents contracting diseases.

1.2 Correlation between Rural "Hollowing Out" and Resident Health

The phenomenon of rural "hollowing out" in Henan Province is particularly prominent. Studies

have pointed out that the outflow of household labor inhibits villagers' participation in habitat environment improvement activities, which can increase the risk of disease transmission and seriously endanger the physical and mental health of the left-behind population [9]. The reasons for this phenomenon are mainly twofold: on one hand, against the backdrop of sustained rapid economic growth and continuous acceleration of urbanization, urban construction, population growth, and lifestyle changes exacerbate the deterioration of rural habitat environments; on the other hand, traditional dwellings have poor physical properties and usability, making it difficult to meet the demands of modern living. It is evident that targeted improvements in the usability and comfort performance of traditional dwellings play a positive role in promoting the healthy development of traditional rural housing.

2 Evaluation and Analysis of Health Performance of Traditional Dwellings in Southern Henan Province

2.1 Evaluation Criteria for Healthy Buildings

In 2014, the WELL Building Standard was introduced as the industry's first standard focusing on the health of occupants within buildings. The WELL Building Standard emphasizes creating a healthy indoor environment and encourages positive lifestyles, with its focus centered on people [10].

In 2016, influenced by the "Healthy China" strategy and international healthy building standards, China developed the "Healthy Building Evaluation Standard" T/ASC02-2016 [11]. This standard is primarily applicable to the evaluation of residential buildings, following the principle of multidisciplinary integration. It emphasizes elements such as air quality, water quality, comfort, fitness, humanities, and services for analyzing and evaluating buildings [12].

2.2 Selection of Evaluation Projects for Health Performance of Traditional Dwellings in Southern Henan Province

Southern Henan Province has a climate characterized by warm winters, hot and humid summers, abundant rainfall, and ample sunlight, with picturesque landscapes everywhere, earning it the reputation of being the "Northern Jiangnan" and the "Jiangnan of the North". As of now, a total of 276 national-level traditional villages have been selected in six batches in Henan Province, with 34 traditional villages from Southern Henan included. These traditional villages are well-situated and integrate well with the natural environment (see Figure 1).

According to research [9], starting from people's perception of factors affecting the healthy living environment, the rural healthy habitat environment can be divided into three parts: residential buildings themselves, living spaces, and social services. Among them, shaping healthy buildings through changes in living spaces and social services is a comprehensive process involving multiple parties and is a daunting and lengthy task. Meanwhile, the focus of residential buildings lies in creating a healthy indoor environment, mainly reflected in aspects such as air quality, light environment, architectural layout, and building materials. Therefore, optimizing the indoor environment through architectural design methods to create healthy spaces is more achievable.



Figure 1: Traditional Villages in Southern Henan Province (Image Source: Liu Congzhong [13])

Therefore, based on the actual situation of traditional dwellings in southern Henan Province, the article focuses on evaluating the health performance of these dwellings from four aspects of indoor environmental quality: thermal environment, light environment, indoor air quality, and sound environment.

3 Evaluation of Health Performance of Traditional Dwellings in Southern Henan Province

3.1 Evaluation of Thermal Environment

For the evaluation of the thermal environment of traditional dwellings in southern Henan Province, on-site investigations and questionnaire surveys were mainly conducted. Questionnaires were distributed to residents during both winter and summer seasons. The questionnaire results show that during the summer, 70% of residents use air conditioning for cooling, 21% of residents use only electric fans for cooling, and 9% of residents do not use any cooling devices (see Figure 2). Among residents who use cooling devices, 70% feel the temperature is moderate, 23% still feel relatively hot, and 7% feel relatively cold. However, residents wish to reduce the time spent using air conditioning. Among residents who do not use cooling devices, they generally feel relatively hot, but the reason for not using cooling devices is to save electricity costs.

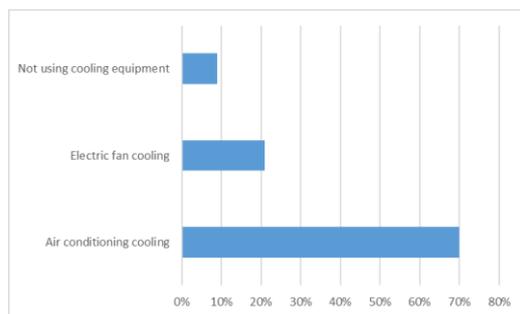


Figure 2: Cooling Methods in Summer (Image Source: Self-drawn)

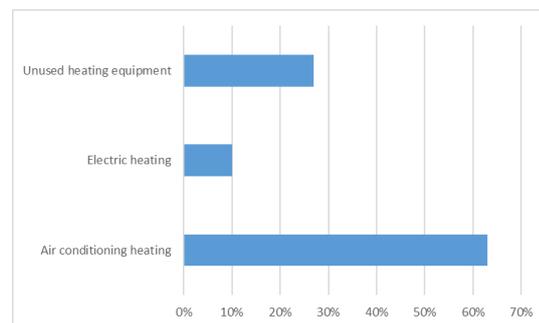


Figure 3: Heating Methods in Winter (Image Source: Self-drawn)

In winter, 63% of residents use air conditioning for heating, 10% of residents use electric heaters for heating, and 27% of residents do not use any heating devices (see Figure 3). Among residents who use heating devices, 81% still wish to further increase the indoor temperature. The thermal sensation evaluations of residents who do not use heating devices are as follows: 83% of residents evaluate the thermal sensation as cold, with 7% of them rating it as very cold.

Through questionnaire analysis, it can be summarized that there are several issues regarding the indoor thermal environment of traditional dwellings in this area: (1) In summer, residents rely on cooling devices to reduce indoor temperatures, with an expectation for cooler indoor comfort. In winter, indoor temperatures are relatively cold when heating devices are not used, with an expectation for warmer indoor comfort. (2) Three types of traditional dwellings are exposed to long-term humid and warm or humid and cold environments, resulting in poor thermal conditions.

It is evident that the indoor thermal environment of traditional dwellings in both summer and winter seasons does not meet the standards and fails to satisfy residents' needs. The indoor living environment is unsuitable, necessitating measures to provide residents with suitable indoor living conditions.

3.2 Evaluation of Light Environment

Traditional dwellings in southern Henan Province typically feature lattice doors and windows as well as ordinary plank doors and windows (see Figure). This results in some drawbacks for traditional dwellings, such as insufficient lighting and ventilation to meet usage needs.

On-site investigations revealed that traditional dwellings generally lack adequate indoor lighting. If the main windows of traditional dwellings are arranged from largest to smallest, they are typically found in the main hall, bedrooms, and kitchen, with the kitchen exhibiting the largest deviation from national standards. The main lighting fixtures indoors are usually LED or incandescent lamps. However, there are safety hazards such as shadows and glare during nighttime activities, as well as a lack of proper lighting guidance or shielding due to the installation of light sources at the central position on the ceiling of each room. Furthermore, the absence of specialized environments and professional lighting equipment for children's studying activities may lead to myopia or other vision-related disorders.



Figure 4: Opening Windows of Traditional Dwellings in Southern Henan Province (Image Source: ZSYN App)

3.3 Indoor Air Quality

Although the external environment surrounding traditional dwellings is favorable, the indoor ventilation is inadequate due to the configuration of doors and windows, particularly in the kitchen and bathroom, where hygiene issues are more severe. Cooking with firewood in the kitchen generates a large amount of smoke, which is a significant source of indoor air pollution. Some bathrooms are dry toilets, while others, despite being equipped with toilets, still fail to meet ventilation and moisture prevention standards. Additionally, some residents have the habit of smoking indoors or burning charcoal indoors during winter, which, coupled with poor ventilation awareness, further degrades indoor air quality.

3.4 Evaluation of Sound Environment

According to research, traditional dwellings in southern Henan Province are carefully selected for their locations, often far away from noise sources such as transportation, industrial production, and construction sites. The outdoor sound environment mainly consists of natural sounds such as wind, rain, and animal noises, resulting in a high-quality sound environment. Particularly at night, the environment is exceptionally tranquil, ensuring local residents can live and work normally. A good, comfortable, and quiet natural sound environment allows villagers to sleep peacefully, ensuring they wake up refreshed for the next day.

4 Strategies for Improving Health Performance of Traditional Dwellings in Southern Henan Province

4.1 Summary of Health Performance Issues in Traditional Dwellings

The analysis results of health performance in traditional dwellings in Henan Province, focusing on thermal environment, light environment, air quality, and sound environment, are summarized in the following table:

Table 1-1 Summary of Health Performance of Traditional Dwellings (Source: Self-drawn)

Health performance	inferiority	Can it be improved
Thermal environment	The indoor temperature and humidity did not meet the standards in both winter and summer seasons, and the thermal environment was poor	Can be improved
light environment	Insufficient indoor lighting effects in buildings	Can be improved
Indoor air quality	Lack of natural ventilation indoors and poor air quality	Can be improved
Acoustic environment	The impact is not significant	Can be improved

The analysis above indicates (Table 1-1) that the main deficiencies in the health performance of traditional dwellings are as follows: (1) Poor thermal comfort during both winter and summer seasons; (2) Insufficient indoor lighting in all areas; (3) Lack of natural ventilation indoors.

4.2 Strategies for Improving Thermal Environment Issues

To address the indoor thermal environment issues in traditional dwellings in southern Henan Province, blindly increasing window area can lead to the destruction of the original appearance of dwellings and is not conducive to reducing energy consumption. Therefore, the focus should be on objective factors such as partial adjustments in building design and thermal insulation properties of building materials. The main strategies include optimizing the window-to-wall ratio and the external envelope structure. The key points of window optimization are as follows: (1) appropriately reducing window area to coordinate with lighting and ventilation; (2) using glass and frames with low thermal conductivity; (3) reducing gaps; (4) enhancing gap airtightness; (5) implementing sunshade measures in summer.

The renovation of the external envelope structure is suitable for using internal insulation methods. Internal insulation has three special advantages in the renovation of traditional rural dwellings: (1) The technology is not complex and is conducive to self-construction, reducing labor costs; (2) The cost is relatively low; (3) It does not damage the traditional appearance of the facade.

4.3 Strategies for Improving Light Environment Issues

The light environment of traditional dwellings includes both natural light and artificial lighting, so improvements should focus on both natural light utilization and artificial lighting settings. In terms of natural light utilization, adjusting the window area, appropriately lowering the window sill height, and optimizing facade lighting efficiency can provide sufficient natural light inside the space. Regarding artificial lighting settings, improvements can be made in three aspects: lamp selection, lighting level settings, and glare control: (1) Lamps should consider that the elderly and children are more sensitive to lighting issues, so it is recommended to set the color temperature at around 4000K, which ensures clear visibility and provides a warm psychological feeling; (2) Combining different light sources in different rooms according to room function and residents' habits, for example, using strip lights and local spotlights in bedrooms, which can be used separately or in combination; (3) Adjusting the height and angle of lighting according to the user's height level and lifestyle habits to avoid direct or reflected glare, and if direct glare cannot be avoided, choose lamps with lampshades.

4.4 Strategies for Improving Indoor Air Quality

The main strategies for improving indoor air quality include optimizing space layout and natural ventilation. Firstly, optimize the layout of main functional rooms such as living rooms, bedrooms, kitchens, storage rooms, and bathrooms according to the living habits of the elderly and children. Under the premise of controlling the appropriate window-to-wall ratio, encourage airflow convection by arranging air inlet and outlet vents as much as possible. Secondly, adhere to the principle of larger

windows on sunny sides and smaller windows on shaded sides when determining window areas. Increase the window area on sunny sides and add high side windows with an area of approximately 0.4 square meters on shaded sides and mountain walls to improve ventilation without increasing room load.

Summary

From the perspective of healthy buildings, this article first analyzed the construction performance of traditional dwellings and the interaction mechanism between the "hollow village" phenomenon and the health status of residents. Under the premise that the performance of building elements can significantly affect indoor environmental indicators, it reviewed the relevant evaluation systems of healthy buildings. Based on these systems, it clarified the evaluation items for the health performance of traditional dwellings in southern Henan Province. The evaluation primarily focused on the indoor environmental quality of traditional dwellings, including thermal environment, light environment, indoor air quality, and sound environment. While respecting the overall architectural style of traditional dwellings in southern Henan Province, the article proposed guiding strategies for improving the health performance of dwellings, including renovation of the external envelope structure, optimization of the window-to-wall ratio, adjustment of interior layout, and optimization of indoor lighting sources.

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