Exploring Human-Centered and Ecological Approaches in Architectural Design Under the Healthy City Concept

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Abstract: As global urbanization accelerates, the health needs of city dwellers and ecological pressures have become increasingly prominent, making the healthy city concept a key guiding principle in urban planning and development. Against this backdrop, architectural design must not only fulfill basic functional requirements but also address the dual imperatives of human health and ecological sustainability. This paper examines pathways toward human-centered and ecological architectural design, using the healthy city concept as its starting point. It analyzes the new requirements healthy cities impose on architectural spatial environments; delves into the practical exploration of human-centered design in spatial experience, community interaction, and intelligent care; and discusses the implementation of ecological design through green building materials, natural integration, and low-carbon renewal. The synergistic advancement of human-centered and ecological approaches is a key direction for realizing healthy city development. This approach enhances residents' physical and mental well-being, improves urban ecological environments, and promotes the sustainable development of both architecture and cities. This discussion holds theoretical significance and practical value for future architectural design innovation and the implementation of healthy city development.

1. Introduction

With accelerating urbanization and rising living standards, urban health issues have increasingly become a focal point of societal concern [1]. Issues such as air pollution, spatial congestion, resource depletion, and ecological degradation not only threaten urban sustainability but also directly impact residents' physical and mental health [2]. Against this backdrop, the concept of “healthy cities” has emerged as a vital guiding principle in global urban planning and development, emphasizing human-centered approaches, prioritizing ecological environments, and advocating for the coordinated advancement of social, economic, and environmental dimensions [3]. As the fundamental units and physical carriers of urban space, buildings play a pivotal role in achieving healthy city objectives [4]. Architectural design transcends mere functional and formal shaping; it regulates the relationship between people and their environment [5]. Its value extends far beyond singular utility, increasingly focusing on human health, social interaction, and ecological sustainability [6]. Design now confronts the critical challenge of balancing human health needs with ecological and environmental demands [7]. Human-centered design emphasizes understanding behavioral patterns, psychological experiences, and social dynamics, aiming to enhance individual and collective well-being through spatial creation [8]. Ecological design prioritizes the conservation of natural resources and environmental protection, promoting symbiotic development between buildings and ecosystems through green materials, energy-saving technologies, and organic integration with nature. The organic combination of these two approaches is not only an essential requirement for healthy city development but also the core direction for future architectural innovation. This paper will analyze and discuss human-centered and ecological architectural design explorations based on the theoretical foundation of the healthy city concept, aiming to provide theoretical support and practical references for healthy city construction.

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2. The Healthy City Concept and New Demands for Architectural Design

The healthy city concept originated from the World Health Organization's Healthy Cities initiative launched in the late 20th century [9]. Its core principle involves improving urban environments and social conditions through scientific planning and management to enhance residents' overall health [10]. Guided by this concept, urban development no longer prioritizes solely economic gains and spatial expansion but places human health as the foremost objective. As a vital component of the urban environment, architecture must reexamine design principles from a health-oriented perspective, strengthening its responsiveness to multiple environmental, social, and individual needs. Energy Consumption of a Building

$$E_{tot} = \sum_{i=1}^{n}\left(E_{heating,i} + E_{cooling,i} + E_{lighting,i} + E_{appliance,i}\right) \quad (1)$$

At the architectural design level, the healthy city concept demands that buildings not only fulfill basic functionality and safety but also prioritize the impact of spatial environments on human physiology and psychology. Adequate natural lighting, effective ventilation, appropriate scale, and comfortable acoustic and visual environments are all crucial factors in promoting physical and mental well-being. Design should address diverse user needs, including the experiences of children, the elderly, and special populations, promoting inclusive and equitable public spaces to achieve genuine human-centered care, showed in Figure 1:

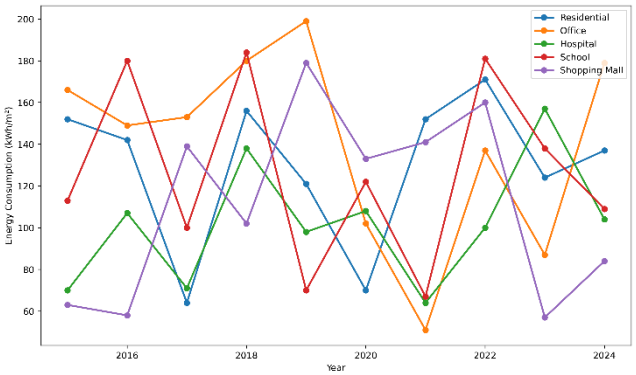

Figure 1 Energy consumption of different building types

Healthy cities emphasize shaping social relationships and community vitality. Architectural design must transcend its traditional role as a mere physical space, increasingly embracing functions that facilitate social interaction and cultural expression. By providing open, shared public spaces that foster neighborhood interaction and community engagement, buildings can become vital platforms for strengthening social cohesion and public health. This social dimension of health requires architects to balance spatial efficiency with social benefits in their designs, forging closer connections between people.

Facing increasingly severe environmental and resource pressures, the concept of healthy cities demands that architecture actively respond at the ecological level. The promotion of green building materials, the application of energy-saving and renewable energy technologies, and measures like rainwater harvesting and recycling have become critical considerations in architectural design. By embedding ecological strategies, buildings can reduce their environmental footprint and foster positive interactions with nature. Thus, the concept of healthy cities not only sets higher standards for architectural design but also charts a course centered on human-centered and ecological principles.

3. Human-Centered Exploration in Architectural Design

As the human habitat continues to evolve, the human-centered philosophy in architectural design has gained prominence. It emphasizes that buildings are not merely physical structures but spatial mediators that impact users' health, comfort, and social interactions. The core of human-centered design lies in prioritizing human needs, achieving deep interaction and emotional connection between architecture and people through optimized spatial experiences, attention to social relationships, and the integration of smart

technologies. Within the context of healthy cities, human-centered exploration manifests in three key areas: First, enhancing users' physical and mental well-being through rational spatial organization and environmental design. Second, strengthening social interaction and a sense of belonging by designing shared community spaces for exchange. Third, leveraging smart technologies and service approaches to amplify buildings' care and convenience for occupants. These three dimensions complement each other, collectively forging a new paradigm of healthy architecture centered on people.

3.1 Spatial Experience and Mental Health

Architectural spaces are not merely physical environments but also crucial foundations for human psychology and behavior. Extensive research demonstrates a strong correlation between spatial experiences and mental health. The healthy city concept emphasizes “people-centeredness,” requiring architectural design to explore how multidimensional factors—such as spatial layout, lighting conditions, air quality, and material textures—impact psychological states from the perspective of users' physical and mental well-being. Through scientifically sound design, environments can be created that alleviate stress, enhance happiness, and promote mental health. Daylight Factor (DF)

$$DF = \frac{E_{in}}{E_{out}} \times 100\% \quad (2)$$

Natural elements play an irreplaceable role in spatial experiences. Abundant natural light not only helps regulate circadian rhythms and improve mood but also reduces the likelihood of depression and anxiety. Good ventilation and air circulation enhance living comfort while lowering the risk of respiratory diseases. The incorporation of natural elements like greenery, courtyards, and water features not only provides visual relaxation but also strengthens the psychological connection between humans and nature through the “biophilia effect,” thereby exerting restorative benefits, showed in Figure 2 :

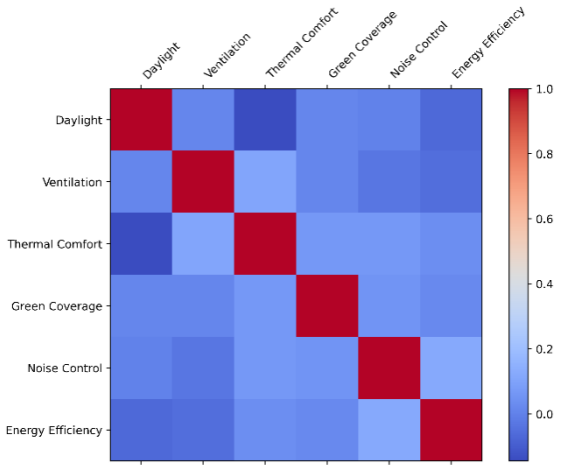

Figure 2 Correlation heatmap of environmental factors

The rationality of spatial scale and functional layout directly impacts psychological perception. Excessively cramped or crowded spaces can induce feelings of oppression and anxiety, while overly expansive spaces lacking zoning may foster a sense of detachment. Appropriate spatial dimensions and flexible functional layouts satisfy individual needs for security and privacy while facilitating communication and interaction. Particularly in residential buildings and public facilities like educational and healthcare institutions, spatial comfort and approachability profoundly influence occupants' psychological states.

Architectural details and ambiance creation are equally crucial. Color schemes, material selections, acoustic environments, and even scent environments subtly influence human emotions and psychology. For instance, soft colors foster warmth and tranquility, natural materials enhance spatial intimacy, and effective acoustic control reduces noise-induced tension. These details not only elevate spatial quality but also

provide nuanced safeguards for mental well-being. Thus, architecture focused on spatial experience fundamentally promotes human psychological health through environmental optimization—a vital embodiment of the healthy city concept.

3.2 Community Interaction and Social Engagement

The development of healthy cities concerns not only individual physical and mental well-being but also the harmony of social relationships. As the fundamental spatial units of community life, buildings' designs directly influence how people communicate and interact socially. Human-centered architectural design focuses not only on individual experiences but also supports and guides group interactions. By rationally organizing space and functions, buildings can become vital mediators for fostering neighborly connections and strengthening community cohesion, thereby enhancing overall societal health indicators. Thermal Comfort (Predicted Mean Vote, PMV)

$$\mathrm{PMV} = (0.303\mathrm{e}^{-0.036\mathrm{M}} + 0.028) \cdot (\mathrm{M} - \mathrm{W} - \mathrm{H}) \quad (3)$$

Shared spaces play a central role in fostering social interaction. Open courtyards, community activity plazas, leisure promenades, and multi-purpose public halls provide natural gathering and interaction points for residents. Designing such spaces requires not only accommodating diverse functional needs but also prioritizing comfort and accessibility, transforming them into inviting nodes where people willingly linger and engage. Through the creation of shared spaces, neighborly relationships can evolve from unfamiliarity to familiarity, gradually forming social networks that strengthen residents' sense of belonging and community identity.

Architectural design can guide social interactions through spatial organization. Thoughtful circulation patterns, semi-open transitional spaces, and the coordinated layout of public and private zones can create more opportunities for chance encounters and conversations without compromising individual privacy. For instance, internal pedestrian walkways and landscape features serve not only as transportation routes and aesthetic elements but also as catalysts for neighborly conversations and daily interactions. Through this “passive socialization,” architecture becomes a key vehicle for extending social networks. Ventilation Rate Requirement

$$\mathrm{Q} = \mathrm{V} \cdot \mathrm{ACH} \quad (4)$$

Architectural spaces should also accommodate cultural activities and community governance functions. Under the concept of healthy cities, communities are not merely living spaces but vital hubs for social culture and public services. By incorporating multifunctional activity rooms, community libraries, cultural galleries, or exhibition spaces, buildings can meet residents' diverse cultural needs while providing platforms for community self-governance and public participation. This design approach, where space supports social interaction, not only enhances residents' social engagement but also promotes community public health and the accumulation of social capital.

3.3 Smart Technology and Human-Centered Care

With the rapid advancement of information technology and intelligent solutions, architectural spaces are evolving from traditional physical forms toward digital and smart environments. Guided by the healthy city concept, the integration of smart technology not only enhances operational efficiency and management standards but, more importantly, delivers more human-centered experiences and care. Smart buildings transcend mere technological accumulation; they prioritize people, using technology to achieve environmental adaptability, personalized services, and refined care.

Smart technologies play a vital role in creating healthy environments. Intelligent monitoring systems track indoor air quality, temperature, humidity, and noise levels in real time, automatically adjusting ventilation, lighting, and HVAC systems to maintain optimal conditions. This dynamic regulation not only enhances comfort but also effectively mitigates potential health risks from adverse environmental factors. Simultaneously, sensor-based smart lighting and shading systems adapt to natural light variations and occupant activity patterns, creating environments aligned with natural rhythms that support psychological well-being.

Smart technology enables personalized services. Different user groups have distinct needs: seniors require accessible entry systems and safety assurances, children need interactive and stimulating spatial experiences, while individuals with disabilities demand meticulous accessibility support. Through the integration of artificial intelligence and big data, buildings can learn and optimize based on users' behavioral patterns and preferences, delivering differentiated services and support. This transforms architectural spaces into environments that truly "understand people."

Smart technologies also unlock new possibilities for humanistic care and societal well-being within buildings. Smart interactive platforms and community applications foster communication and mutual assistance among residents, while smart healthcare and remote health monitoring provide more convenient avenues for individual health management. Additionally, intelligent security systems enhance residential safety, and virtual reality (VR) and augmented reality (AR) technologies offer novel experiences for education, culture, and leisure activities. Collectively, these applications ensure smart buildings not only serve human needs functionally but also respond to the human-centered values emphasized by healthy cities on an emotional and caring level. Carbon Emission of Building Lifecycle

$$C_{total} = \sum_{j=1}^{m}\left(C_{material,j} + C_{construction,j} + C_{operation,j} + C_{demolition,j}\right) \quad (5)$$

4. Ecological Practices in Architectural Design

Within the framework of healthy city concepts, architectural design must not only prioritize human physiological and psychological well-being but also shoulder responsibilities for ecological conservation and sustainable development. As significant contributors to energy consumption and carbon emissions, buildings' ecological transformation holds critical importance for alleviating environmental pressures and advancing green urban development. Ecological design transcends isolated technologies, instead employing comprehensive strategies—including material selection, energy utilization, environmental integration, and circular renewal—to achieve harmonious coexistence between architecture and nature.

The application of green building materials and energy-saving technologies forms the foundation of ecological design. Green materials impose minimal environmental burdens during production, use, and recycling while ensuring healthy indoor environments. Energy-saving technologies effectively reduce operational energy consumption through high-efficiency insulation systems, low-energy HVAC and lighting equipment, and renewable energy utilization. For instance, integrating solar photovoltaic panels and geothermal heat pumps not only achieves energy self-sufficiency but also reduces reliance on fossil fuels, setting a benchmark for low-carbon buildings in healthy cities.

The integration of architecture with the natural environment is a defining characteristic of ecological design. Through green roofs, vertical greening, and ecological courtyards, buildings incorporate natural elements into their spaces. This not only improves local microclimates and air quality but also provides residents with opportunities to connect with nature. Simultaneously, the application of rain gardens, ecological wetlands, and permeable paving effectively regulates urban stormwater issues and enhances the self-repair capacity of urban ecosystems. This deep integration with the natural environment transforms buildings into organic components within the healthy city ecosystem. Water Recycling Efficiency

$$\eta_{water} = \frac{V_{recycled}}{V_{total}} \times 100\backslash\% \quad (6)$$

Building renewal and retrofitting under circular economy and low-carbon principles also represent significant directions for ecological practice. As the stock of existing buildings in cities grows, enhancing their utility and ecological performance through green retrofits has become a critical challenge in architectural design. Utilizing recyclable materials and promoting modular and prefabricated construction methods can reduce resource consumption while improving construction efficiency. Monitoring and optimizing the entire building lifecycle through smart management platforms not only achieves efficient energy utilization but also advances low-carbon operations and sustainable development goals.

Ecological practices in architectural design encompass multiple dimensions including materials, energy, environment, and management. At its core, this approach leverages scientific and technological means to foster harmonious coexistence between buildings and the natural environment. Ecological architecture not only reduces environmental burdens but also complements human-centered design, collectively shaping the vision of healthy cities.

5. Conclusion

The concept of healthy cities provides contemporary architectural design with new value orientations and development pathways. Guided by this philosophy, buildings transcend mere physical structures to become mediators of relationships between people and the environment, society and ecology. This paper explores the new demands healthy cities place on architecture, examining human-centered design practices in spatial experience, social interaction, and intelligent care, alongside ecological design approaches in green building materials, environmental integration, and circular renewal. Research indicates that human-centered and ecological approaches are not mutually exclusive but rather form the indispensable dual pillars of healthy city development: the former focuses on human needs and experiences, emphasizing individual health and improved social relationships; the latter centers on the environment and resources, stressing harmonious coexistence between humans and nature. Their synergistic development not only enhances the physical and mental well-being of urban residents but also propels the green transformation and sustainable development of the architectural industry. Looking ahead, with the continuous advancement of smart technologies and the deepening of ecological concepts, architectural design will assume increasingly diverse roles in healthy city development. Its human-centered values and ecological significance will become more prominent, providing robust support for achieving harmonious coexistence between people and buildings, as well as cities and nature.

References

[1] Zainul Abidin N, Pasquire C L. Delivering sustainability through value management[J]. Engineering, 2013, 12(2):168-180.

[2] Bolla R, Khan R, Repetto M. Assessing the Potential for Saving Energy by Impersonating Idle Networked Devices[J]. IEEE Journal on Selected Areas in Communications, 2016, 34(5):1676-1689.

[3] Yuzhuo W, Yuanyuan Y. Geodesy ecological perspective of architectural tectonics in green building design[J]. Arabian Journal of Geosciences, 2021, 14(17):1-11.

[4] Howard, Elisabeth D. Optimizing the Birth Environment With Evidence-Based Design[J]. Journal of Perinatal & Neonatal Nursing, 2017, 31(4):290.

[5] Meffert, Philipp, Bischoff, et al. Significance and function of different spinal collateral compartments following thoracic aortic surgery: immediate versus long-term flow compensation[J]. European Journal of Cardio-Thoracic Surgery, 2014, 45(5):799-804.

[6] Wex T, Kuester D, Klaus Mnkemüller, et al. Assessment of desmosomal components (desmoglein 1-3, plakoglobin) in cardia mucosa in relation to gastroesophageal reflux disease and Helicobacter pylori infection[J]. Human Pathology, 2012, 43(10):1745-1754.

[7] Zou W, Wang Y, Tian E, et al. A New Dynamic and Vertical Photovoltaic Integrated Building Envelope for High-Rise Glaze-Facade Buildings[J]. Engineering, 2024, 39(8):194-203.

[8] Grobman Y J, Weisser W, Shwartz A, et al. Architectural Multispecies Building Design: Concepts, Challenges, and Design Process[J]. Sustainability, 2023, 15(21):29.

[9] Salman H S, Laing R, Conniff A. The impact of computer aided architectural design programs on conceptual design in an educational context[J]. Design Studies, 2014, 35(4):412-439.

[10] Chowdhury S, Noguchi M, Doloi H. Conceptual Parametric Relationship for Occupants' Domestic Environmental Experience[J]. Sustainability, 2021, 13(5):27.