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Promoting Health and Well-Being: Environment Design of Rehabilitation Centers for Autistic Children Under the Theory of Restorative Environment

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Abstract

At present, the design of autism rehabilitation centers in China generally fails to meet the rehabilitation needs of patients, making it difficult to achieve the health and well-being goals of sustainable development. In this context, restorative environment theory, with its potential to improve spatial environments and enhance well-being, has gradually become a key driving force in the environmental design process. Therefore, this literature review employs a combined approach of macro-level quantitative and micro-level qualitative research methods based on the Web of Science (WOS) database. First, 5953 relevant literature sources were analyzed to reveal the research background, current status, hot topics, and future development trends of the theory of restorative environment and rehabilitation centers for children with autism. Through keyword network visualization, seven primary clusters were identified: #0 environmental design, #1 burnout, #2 Autism specturn disorder, #3 Attention deficit hyperactivity disorder, #4 caregiver, #5 domiciliary care, # 6 stroke. These clusters were further synthesized into four core design elements: lifecycle-spanning design, family collaboration and community engagement design, green sustainable environment design, and culturally inclusive and diverse physical and mental development design. Subsequently, a multi-level case analysis was conducted using 24 global autism-friendly design examples to validate the practical applicability of these core elements. Finally, based on the research findings, the discussion section proposes environmental design strategies for autism rehabilitation centers tailored to the Chinese context.These strategies aim to enhance the well-being of children with autism and contribute to the achievement of Sustainable Development Goal 3 (SDG3).

Keywords: autistic children; rehabilitation centers; environmental design; restorative environment theory; sustainable development goal 3 (SDG3)

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1. Introduction

In recent years, the incidence of autism in children has shown rapid growth worldwide. Many national security departments have actively promoted the construction of healthcare institutions such as rehabilitation centers for children with autism. However, autism rehabilitation centers in some countries, such as China, still generally neglect environmental construction, have an insufficient understanding of the rehabilitation value of spatial resources, and have not yet incorporated environmental therapy into the routine

intervention system [1]. The design of rehabilitation environments for children with autism continues to face significant challenges, failing to meet their physical and psychological needs [2]. In order to better achieve the United Nations Sustainable Development Goal SDG3 "Ensure good health and well-being for all ages", the design of rehabilitation centers oriented to promote the health and well-being of autistic children has become the focus of policy guidelines [3].

As background, the Restorative Environment Theory, with its unique value in environmental intervention and health promotion, provides important theoretical support for innovative design paradigms in rehabilitation centers for children with autism. The theory was first proposed in 1983 by Stephen Kaplan and Rachel Kaplan, environmental psychologists at the University of Michigan. It refers to the function of the surrounding environment to restore and renew the physical and mental resources and abilities that people expend.This type of environment offers tremendous healing benefits, providing physical and mental pleasure while reducing stress.The entire theory is based on universal adaptability and is a process of positive transformation of the mind and body [4].

In 1989, Kaplan summarized the characteristics of the theory of restorative environment in four dimensions: Being away, Extent, Fascination, and Compatibility [5]. As an important branch of psychology, the four core features of the restorative environment theory emphasize the importance of therapeutic care, the interplay between man and nature, and overall well-being, and are of great value to urban construction, public health, psychotherapy, and medical development [6].

The design of the autism rehabilitation center focuses on guiding autistic children to interact positively with their environment, such as creating predictable spatial layouts and interactive areas to promote the development of their social skills [7]. This design concept not only provides autistic children with a safe, comfortable, and inspiring environment but also effectively supports their social, cognitive, and emotional development, thereby significantly improving their quality of life. For example, the Beijing UNStudio Children's Rehabilitation Clinic is inspired by coastal mountain sceneries, sunset colors, and the concept of a mountain wilderness playground. It integrates sound-absorbing elastic areas with parent-child co-therapy zones to establish a secure, predictable, and multi-sensory therapeutic environment that mitigates anxiety in children with autism and enhances their social capabilities. Additionally, the Murr Autism Center in the United Arab Emirates employs a "quiet and simple" design principle, minimizing spatial details and emphasizing natural light and neutral color tones to reduce sensory overload. This design effectively improves cognitive abilities in children with autism and reduces environmental stress through acoustic and ventilation design, creating a rehabilitation and healing space for individuals with autism. The above case study demonstrates the rehabilitation center's efficient and flexible strategies for space utilization, as well as its human-centric spatial design philosophy. This ideology seeks to improve the rehabilitation experience of autistic individuals by establishing a superior environment that promotes their well-being.

Despite the increasing awareness of autism rehabilitation clinics, such institutions remain significantly inaccessible on a worldwide scale. Conventional restoration building strategies are insufficient to tackle contemporary resource deficiencies and environmental challenges. A review of the literature shows that the application of restorative environment theory in autism rehabilitation centers remains inadequate, and there is relatively little research on its integration with SDG 3 ("Ensure healthy lifestyles and promote well-being for all ages").Most existing studies focus on the theory of restorative environment in single settings, such as educational spaces for children with autism, using design strategies like sensory healing [8] and natural healing [9] to effectively improve the physical and mental health, as well as the quality of life, of people with autism.Consider Hoda Shahmohamma-

dian's team as a case study. Despite advocating for the advantages of integrating natural features, they did not address the practical inconsistencies of low-cost, highly adaptable design, hindering large-scale implementation.

Therefore, this literature review aims to explore the application value of the restorative environment theory in designing rehabilitation environments for children with autism. First, through quantitative research methods in bibliometrics, we systematically organized relevant literature on rehabilitation environment design for children with autism under this theory, distilling four core design principles and examining their current status, key issues, and future trends. Second, through qualitative analysis, we validated the applicability of the aforementioned key points in real-world cases by selecting 24 representative design examples and conducting an in-depth analysis of their design philosophies. This led to the formulation of environmental design strategies for Chinese autism rehabilitation centers guided by the theory of restorative environments, aimed at enhancing the health and well-being of children with autism.

2. Materials and Methods

As shown in Figure 1, the research process in this paper is divided into two major phases. The first phase involves data integration and organization, encompassing problem definition, database search, selection criteria, and quality standards. The second phase focuses on the evaluation and analysis of data content, involving macro-level quantitative data analysis and micro-level qualitative content analysis. Finally, the research findings are discussed.

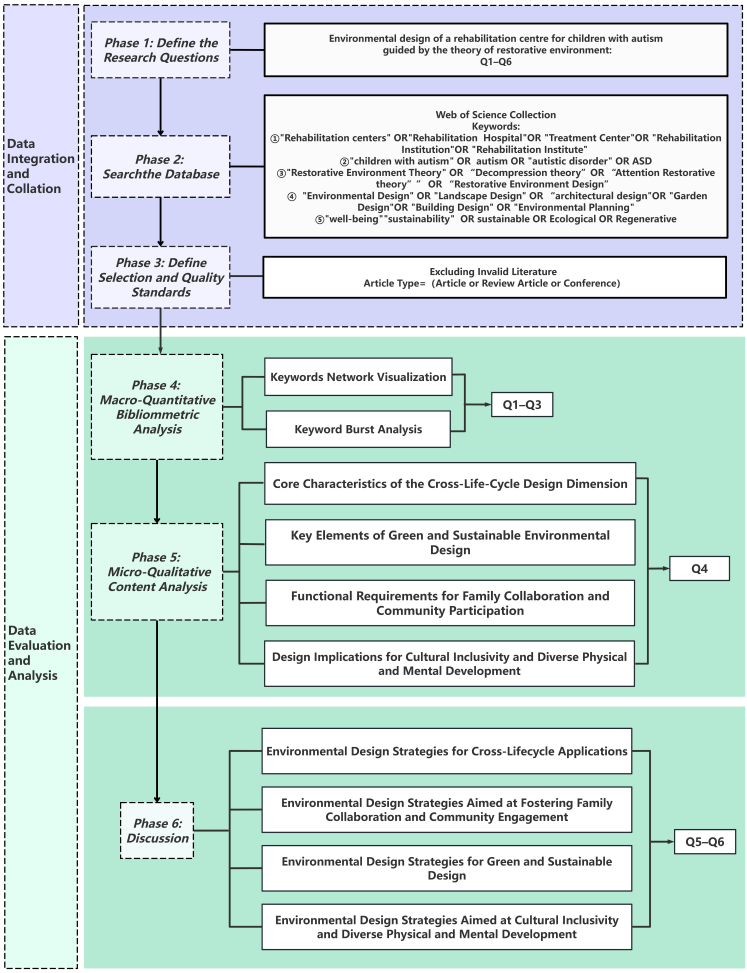

Figure 1. Flowchart of the research methodology (generated by the authors).

2.1. Phase 1: Defining the Research Question

As previously discussed, the design framework established by the restorative environment theory holds potential to address the diverse physical and cognitive needs of children with autism. Therefore, this study aims to address the core research question "The application value of restorative environment theory in designing rehabilitation environments for children with autism, and proposing specific environmental design strategies for Chinese autism rehabilitation centers." The following sub-research questions are identified (Q1–Q6):

Q1: What is the research background of autism rehabilitation centers and the theory of restorative environment?

Q2: What is the current state of research on autism rehabilitation centers and the theory of restorative environment?

Q3: What are the current research hotspots in the field of autism rehabilitation centers and the theory of restorative environment?

Q4: What specific spatial design elements impact the well-being of children with autism?

Q5: How can the four core characteristics of restorative environment theory – Being away, Extent, Fascination, and Compatibility – guide the environmental design of autism rehabilitation centers?

Q6: In alignment with Sustainable Development Goal (SDG) 3, how can environmental design promote the health and well-being of children with autism and their caregivers?

2.2. Phase 2: Searching the Database

In this study, based on bibliometric analysis, the Web of Science (WOS) core ensemble database was selected as the source of data collection, as it is considered an authoritative data source for conducting bibliometric analyses due to its wide coverage and high-quality literature. First, the WoS Core Collection encompasses a broad range of disciplines, including the social sciences (SSCI) and science (SCIE), making it well-suited for interdisciplinary research on rehabilitation design for children with autism, thereby ensuring the diversity of literature coverage on related topics. Second, WoS is one of the largest and most comprehensive databases in the world, encompassing over 8700 academic journals. It is regarded as the most authoritative scientific indexing tool, ensuring the high quality and reliability of the literature [10]. Finally, WoS provides sophisticated scientometric functions that facilitate tracking the core literature and academic evolution of the theory of restorative environment [11,12]. Therefore, this paper is based on the Web of Science (WOS) database and uses a combination of macro-quantitative and micro-qualitative research methods for analysis. The search strategy was built around the core question of "the potential of the theory of restorative environment to enhance well-being in the design of rehabilitation centers for autistic children", following the logical framework of "place-object-theory-means-goal."

The spatial dimension emphasizes "rehabilitation centers for autistic children," with "rehabilitation centers" as the central phrase, encompassing "treatment centers," "rehabilitation institutions," and "rehabilitation institutes." The object dimension is based on "autistic children" combined with "ASD" and "autistic disorder" and other clinical diagnostic terms. Through this series of synonymous expressions, the search is expanded to strengthen the precise positioning of the group of autistic children and the rehabilitation space.

The theoretical framework is based on the "Restorative Environment Theory" proposed by Kaplan and Talbot of the University of Michigan in 1983. This theory integrates two core concepts: the "Decompression Theory" and the "Attention Restorative Theory," emphasizing the restorative effects of exposure to natural environments on physical and mental health. The study further introduces "Restorative Environmental Design," proposed by Stephen R. Kellert of Yale University, which extends the theoretical foundation of restorative environmental design to design practice through the integration of "biophilic design"

and the concept of sustainability. Therefore, this paper takes "Restorative Environment Theory" as the core term and extends it to cover "Decompression Theory," "Attention Restorative Theory," and "Restorative Environmental Design."

The instrumental dimension focuses on the context of the environmental design discipline, choosing "environmental design" as the core term and expanding to cover "landscape design," "architectural design," "garden design," "building design," and "environmental planning" to analyze the potential of the restorative environment theory in the environmental design of rehabilitation centers for autistic children. Since "well-being" encompasses health and is one of the SDGs, the goal dimensions focus on "well-being" and "sustainability" and extend to cover "ecological" and "sustainable," "sustainability," "sustainable" and "ecological," and "regenerative" to explore the current state of research on the pathway to health and well-being in the SDGs for rehabilitation centers for children with autism.

Based on the search data from cross-disciplinary research on rehabilitation centers and children with autism (Table 1), existing literature focuses on foundational studies examining facility functionality and population needs.An inquiry using the keywords "rehabilitation centers and autistic children" produced 91 papers, signifying a considerable study foundation in this domain. Nevertheless, when the study objectives of well-being and sustainability were combined, the number of publications decreased markedly; only six papers addressed the issue of "well-being." This indicates that contemporary research prioritizes the fundamental service activities of rehabilitation centers, whereas the investigation of systematic techniques to improve the well-being of children with autism and the sustainable development of facilities remains nascent.

A systematic literature search and review from the perspective of restorative environment theory regarding the article's research objectives revealed (Table 1) that the application of restorative environment theory (RET) and rehabilitation center scenarios has not been sufficiently researched. Only 4 studies have explored the theory's relevance to "well-being" or "sustainability" solely.The implementation of restorative environment theory in medical architecture and healing landscapes has been observed in China, but not in other nations. Moreover, the application of this theory to the particular context of rehabilitation clinics for autistic children has not yet commenced.

The search data from the perspective of the environmental design discipline reveals a significant research divide between the goals of "well-being" and "sustainability." There are 379 articles on the topic of "environmental design" and "well-being," while there are 5045 studies on "environmental design" and "sustainability." The number of studies on "environmental design" and "sustainability" is 5045, indicating that both research elements are hot topics in the discipline. There have been 157 studies on the theme "Well-being, sustainability, and environmental design." However, when the research scenario focuses on rehabilitation centers, the number of publications shrinks to 5, and there are only 2 publications that integrate with the autistic children's population. It can be seen that most existing environmental design research focuses on general-purpose public spaces and pays insufficient attention to the rehabilitation and medical scenarios of autistic children's groups; the content of research related to secondary well-being is at the initial stage.

Table 1. Number of Document Searched.

Keywords	Number of Documents Searched
TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=("children with autism" OR autism OR "autistic disorder" OR ASD)	91
TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=("well-being")	163
TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	99
TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=("children with autism" OR autism OR "autistic disorder" OR ASD) AND TS=("well-being")	6
TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=("children with autism" OR autism OR "autistic disorder" OR ASD) AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	0
TS=("Restorative Environment Theory" OR "Decompression theory" OR "Attention Restorative theory" OR "Restorative Environment Design") AND TS=("Well-Being")	2
TS=("Restorative Environment Theory" OR "Decompression theory" OR "Attention Restorative theory" OR "Restorative Environment Design") AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	2
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=("Well-Being")	379
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	5045
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=("Well-Being") AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	157
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute")	5
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=("children with autism" OR autism OR "autistic disorder" OR ASD)	2
TS=("Environmental Design" OR "Landscape Design" OR "architectural design" OR "Garden Design" OR "Building Design" OR "Environmental Planning") AND TS=("Rehabilitation Centers" OR "Rehabilitation Hospital" OR "Treatment Center" OR "Rehabilitation Institution" OR "Rehabilitation Institute") AND TS=(sustainability OR sustainable OR Ecological OR Regenerative)	2

Consequently, keyword combinations included dual-keyword and multi-keyword cross-retrieval, with various field combinations, such as title and abstract, being evaluated. Results demonstrated no significant differences in retrieval outcomes. This study utilized theme fields for systematic retrieval to thoroughly elucidate the research state of each term and the developmental potential of their intersecting domains, resulting in a total of 5953 retrieved papers. This logical framework guarantees the thoroughness and accuracy of the literature search while offering theoretical foundations and scholarly backing for ensuing design activities.

2.3. Definition Selection and Quality Criteria

The above phase retrieved a large volume of studies, including duplicates and results with low or no relevance to the research question. Screening should be conducted according to the following criteria:

(1) Since the concept of "The Theory of Restorative Environment" was first proposed by Professor Stephen R. Kellert in 1983, the literature selection period covers publications from 1983 to 2024.
(2) Filter out duplicate documents.
(3) Exclude publications unrelated to the research project on rehabilitation centers for children with autism.
(4) Exclude studies that did not mention the design.
(5) Exclude non-English literature.

Based on the screening criteria outlined in items 1–5 above, a total of 276 articles were retained for macro-level quantitative analysis (Figure 2).

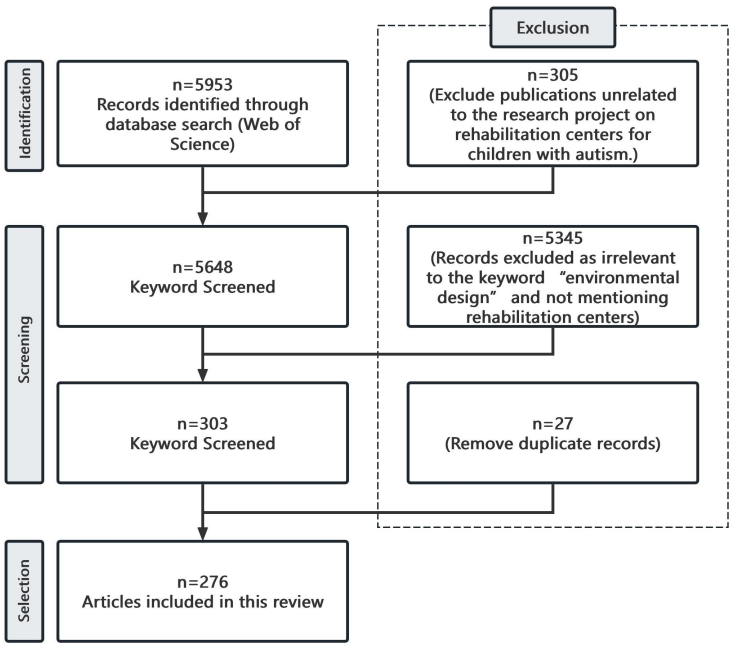

Figure 2. PRISMA flow diagram (created with ProcessOn by the authors).

2.4. Case Analysis and Discussion

This section aims to systematically identify and conduct in-depth analysis of representative cases that provide authentic insights into the phenomena under study (Figure 3).

Case studies were sourced from multiple channels to ensure comprehensive coverage of design typologies and regional variations, including internationally renowned design awards (such as the Red Dot Award and iF Design Award) and practical projects. Following

rigorous selection, 24 representative cases were ultimately identified to reflect conditions across different regions.

To examine how the proposed four core design principles apply in practice, this study developed a multi-level case analysis methodology based on macro-level quantitative and micro-level qualitative analysis.

To ensure the comprehensiveness and relevance of the case database, the following inclusion criteria were adopted:

- The case study must center on a rehabilitation environment designed for children with autism;
- It must incorporate design elements of the restorative environment theory;
- Published between 2012 and 2025 in a renowned design award database or on an official website;
- Information must be publicly accessible.

Although some cases are conceptual in nature, they are only included when they demonstrate feasible, user-centered, and autism-friendly design.

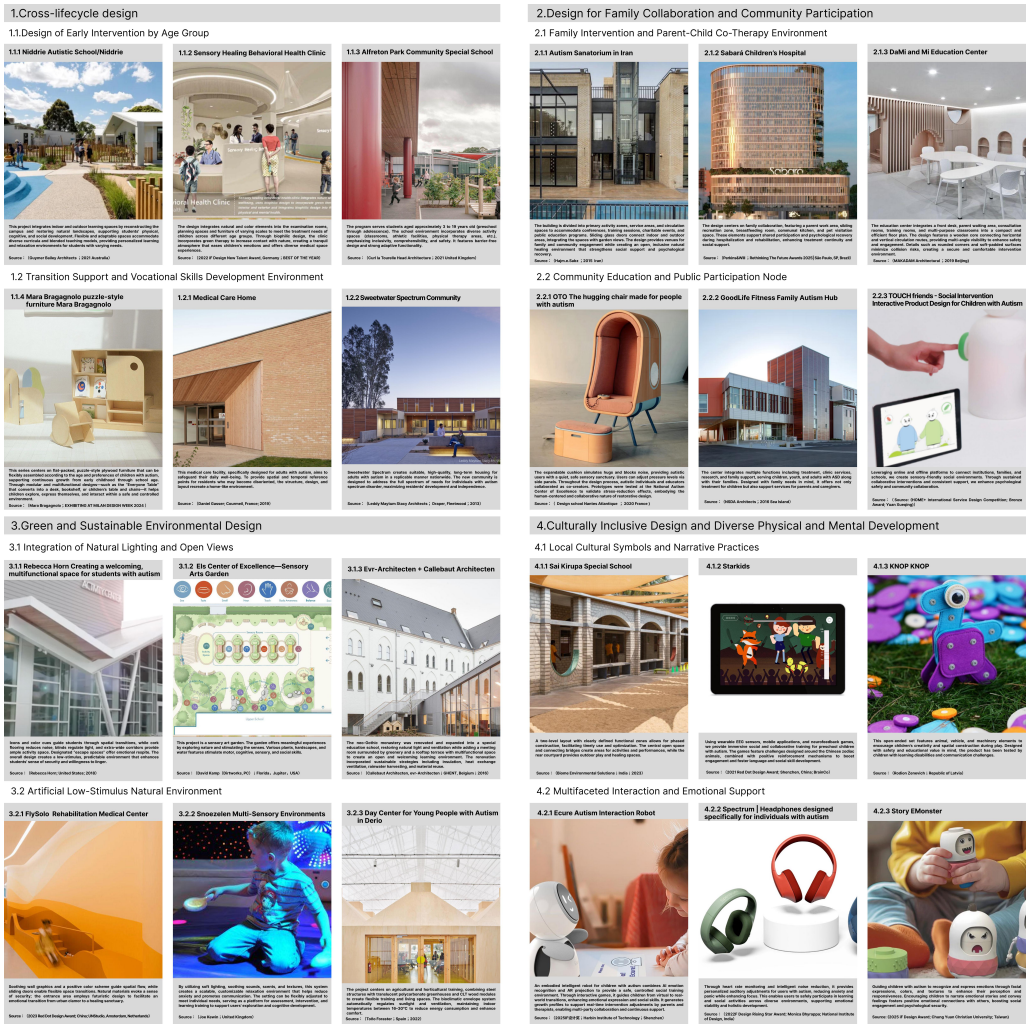

Figure 3. Typical Project Review in the Case Study (Generated by the Author).

2.5. Quantitative and Qualitative Analysis

During this phase of the investigation, the Citespace 6.4.1 software was utilised to perform comprehensive citation visualisation and analysis of pertinent data from the Web of Science (WOS) database.The procedure comprised three sequential steps. First, CiteSpace was employed to perform a co-occurrence analysis of keywords to capture the current

landscape and research hotspots related to "rehabilitation centers," "autism," "RET," and "health." Concurrently, a burst-detection analysis was conducted to identify emergent terms and reveal temporal trends across different time periods. Second, a keyword network visualization was constructed to distill four core design elements, which were then examined through micro-level qualitative content analysis of 24 representative cases to explore pathways by which rehabilitation center design supports children's well-being. This multi-step approach establishes a solid foundation for proposing evidence-informed design strategies for autism rehabilitation centers in China, enabling a more objective and comprehensive understanding of the prevailing research landscape and embedded thematic trends.

3. Results

This section presents findings from both macro-level quantitative bibliometric analysis and micro-level qualitative content analysis. First, Section 3.1 systematically reviews relevant literature on rehabilitation environment design for children with autism under this theoretical framework through quantitative analysis, exploring its current status, key research areas, and future trends. Second, Section 3.2 distills four core design principles based on bibliometric findings. Finally, Section 3.3 validates these four core elements by examining autism-friendly design case studies. It delves into their design philosophies and explores pathways through which rehabilitation center design supports children's well-being. This lays the groundwork for developing concrete environmental design strategies for autism rehabilitation centers in China.

3.1. Results of Macro Quantitative Bibliometric Analysis

This study utilized CiteSpace (version 6.1.R1) software to review current well-being research on the theory of restorative environment, which informs the design of sustainable rehabilitation centers for autistic children. Created by Dr. Chaomei Chen at Drexel University, the program serves as a specialised instrument for visualising and analysing scientific knowledge graphs [13], incorporating information visualisation techniques, bibliometric principles, and data mining methodologies. It can methodically elucidate the framework and evolutionary patterns of a certain research domain. Analysing the co-linear network of countries and authors [14] systematically elucidates the key research capabilities and collaborative networks within the research domain. Keyword clustering analysis helps to identify key areas and emerging trends, while emergent words can keenly capture research hotspots and cutting-edge dynamics [15]. Overall, through multidimensional knowledge mapping analysis, CiteSpace can systematically reveal the evolution, research hotspots, and future trends of the theory of restorative environment in the design of rehabilitation centers for autistic children and provide a quantitative basis for grasping the dynamics of disciplinary development.

3.1.1. Network Analysis

- Keyword Network Visualisation

A keyword is a concise of summary the topic of the literature. For the effective literature, the data will be imported into CiteSpace for keyword co-occurrence analysis, with the keyword as the unit of analysis, excluding duplicated and not strongly related nodes, and finally there are a total of 447 nodes and 1435 lines; the node density is 0.0144, and the number of edges is higher. The links between nodes are greater, but the density is relatively low, and the network structure is relatively sparse. The Q-value (modularity) of the number of modules for this clustering view is 0.6635, indicating a high degree of modularity in the network and significant independence between the clusters. Ultimately,

the top 7 clusters with average profile values $S > 0.6$ were selected for analysis. When $S > 0.5$, it has a reasonable clustering effect, while when $S > 0.6$, clustering is efficient and credible, and at $Q > 0.3$, the clustering map view has an obvious structure. This map has a clear structure and a better clustering effect [16]. The Weighted Mean Silhouette (WMS) S-value is 0.8684, indicating that the internal consistency of this clustering result is high, the nodes within each cluster are strongly correlated, and the overall classification effect is better. Among them, the larger clusters (e.g., #0 and #3) have relatively higher profiles, which further suggests a high degree of internal correlation among them and a concentration of research themes. The resulting keyword co-occurrence mapping of the research areas from 1983 to 2024 is shown in Figure 3.

The network visualization constructed by the CiteSpace software tool is shown in Figure 4, which presents the correlation between keywords through multi-dimensional visual elements (e.g., text, nodes, connecting lines, color blocks, etc.) [17]. Larger nodes signify more frequently cited keywords, whereas thicker lines denote stronger relationships between them, with the line thickness typically proportional to the frequency of keyword co-occurrence [18]. The colour of the keyword mapping relationship line transitions from a cooler blue to a warmer yellow, signifying a progression from earlier to more recent times. The variously coloured distance clusters elucidate linkages both within and among clusters, while the term clustering map signifies distinct research focal points in the domain.

To test the robustness of the analysis results, given that VOSviewer does not directly provide clustering statistical parameters, this study used CiteSpace's modularity (Q = 0.3) and average contour value (S = 0.5) as benchmarks to manually verify the top 8 core clusters in VOSviewer (version 1.6.20). The results showed that the key node documents were highly overlapping between the two tools, and the semantic consistency of the cluster theme keywords indicated that the two tools have substantial equivalence in terms of knowledge structure segmentation.

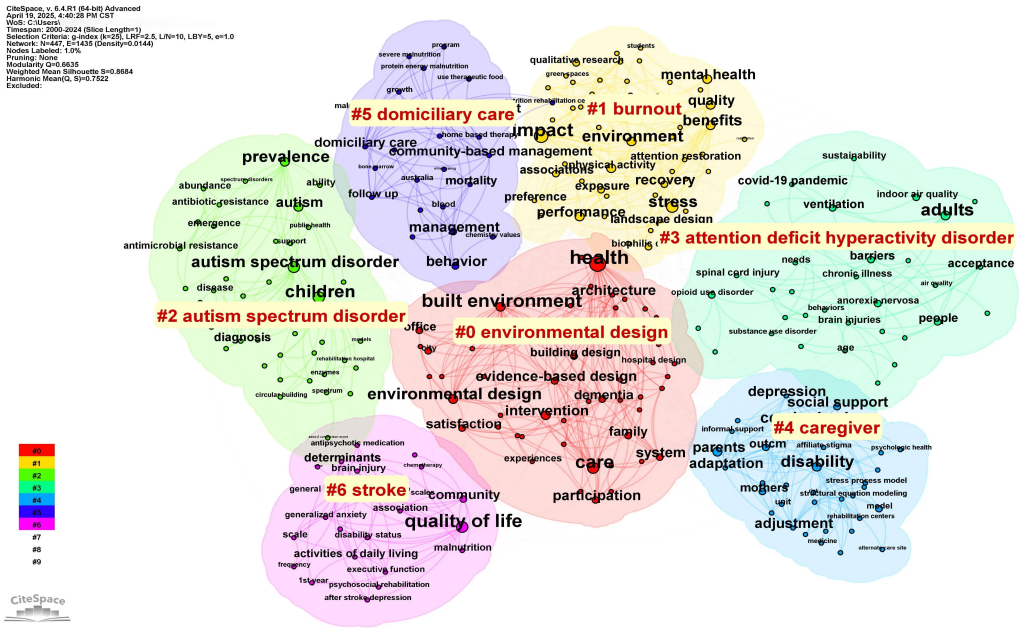

Figure 4. Keyword co-occurrence network diagram generated using CiteSpace (version 6.1.R1) for research topics related to the theory of restorative environments and autism rehabilitation environments (selecting the top 7 clusters with average contour values S > 0.6) (generated by the authors).

The keyword co-occurrence analysis performed with CiteSpace software produced seven clusters. The clustering analysis reveals that the research domain is systematically organised into seven distinct clusters, which collectively illustrate an evolutionary continuum from conventional therapeutic methods to advanced rehabilitation environment support systems (as shown in Figure 4).

Cluster #0, denoting “environmental design,” holds a central location inside the knowledge map.The extensive array of nodes and intricate connections indicate the advanced state of study in the design discipline and its interrelations with domains such as medicine, architecture, and psychology. This cluster includes terms like “built environment,” “evidence-based design,” and “health,” and transcends conventional spatial design to investigate the complex interactions between surroundings and human health, psychological well-being, and social welfare [19]. The essence of this progression is seen in the extensive implementation of approaches like “evidence-based design,” which seeks to enhance healthcare rehabilitation environments through scientific evidence, therefore facilitating user recovery and well-being [20]. This multidisciplinary relationship demonstrates specific imbalances in content. Comprehensive study indicates that contemporary research generally emphasises macro-level theoretical frameworks, focussing mostly on the overarching design of general healthcare environments or extensive medical facilities [21]. Adequate theoretical frameworks and practical applications addressing the distinct sensory processing patterns, cognitive-behavioral traits, and environmental adaptation requirements of neurodiverse groups, including individuals with autism spectrum disorders, are still insufficient. This creates a disparity between macro-level health environment design and micro-level, needs-oriented specialised design [22]. Consequently, the forthcoming advancement in this domain hinges on the profound integration of the distinct requirements of neurodiverse populations into evidence-based design frameworks, thereby facilitating a paradigm shift in environmental design from universal accessible to tailored assistance.

Current research on rehabilitation support systems is evolving from the traditional healthcare institution-centered model toward a comprehensive support framework that integrates environmental, social, and service components. The core issue within this system concerns individual psychological stress and burnout [23]. Specifically, the research encompasses three dimensions: environmental design interventions, social support, and service innovation. First, Cluster #1 centers on "burnout," with the keyword ‘stress’ being the most prominent node. It is closely connected to nodes such as "landscape design," "recovery," and "environment," revealing the crucial role of environmental design as a key intervention in alleviating stress and promoting psychological recovery [24]. However, previous research has predominantly focused on quantitative analyses of psychological stress, lacking empirical exploration of spatial design as an intervention to alleviate stress.Therefore, future research will integrate environmental psychology, behavioral science, and design studies to develop actionable design solutions [25].

The intricate network established by Cluster #4 carers, centred around key nodes such as “parents,” “disability,” and “social support,” underscores the essential importance of social support for the mental well-being of carers [26] [Parental Concerns about the Future of Children with Autism: A Qualitative Study in Iran]. Related research reveals that women frequently endure heightened psychological loads and emotional stress during prolonged caregiving [27]. Nonetheless, current designs lack empirical investigation into how rehabilitation centre environments might effectively mitigate this issue, particularly depending on scale assessments of stressors such as maternal education level, family size, and economic income [28]. As a result, contemporary design techniques frequently do not satisfy the practical requirements of carers. To rectify this significant deficiency,

rehabilitation environment design must surpass the child-centered paradigm and prioritise carers' psychological and social needs equally.

Ultimately, terms like "domiciliary care" and "community-based management" in Cluster #5 collectively indicate the expansion of service models from hospitals to communities and residences [29]. Community-based service models facilitate the decentralisation and accessibility of rehabilitation resources, allowing a greater number of patients to obtain long-term rehabilitation support in familiar living circumstances. This paradigm underscores the significance of continuity and environmental flexibility, attracting considerable interest in chronic disease treatment and mental rehabilitation [30]. This transition theoretically improves care continuity and personalisation. Nonetheless, actual implementation encounters obstacles such as resource shortages, variable service quality, and insufficient professional training for carers. Future advancement necessitates policy endorsement, methodical spatial planning, and occupational education to guarantee sustainable and equitable care services.

Regarding traditional medical research, Cluster #2 (autism spectrum disorder) and Cluster #3 (attention deficit hyperactivity disorder) represent two closely related research directions within the field of neurodevelopmental disorders. Both focus on the interaction between the individual and their environment and social support systems [31] during the developmental process. Furthermore, ASD and ADHD frequently exhibit high comorbidity rates and overlapping symptoms in clinical practice [32], further reinforcing the intrinsic connection between these two cluster themes. Cluster #2 centers on Autism Spectrum Disorder (ASD), with core keywords including "diagnosis" and "prevalence." It focuses on diagnosis, intervention, and management for children, emphasizing their special needs and themes related to environmental factors [33]. Cluster #3 centers on Attention-Deficit Hyperactivity Disorder (ADHD), with the keyword node "adult" being particularly prominent. This indicates that research in this field has expanded from childhood to adulthood, viewing ADHD as a neurodevelopmental disorder spanning the entire lifespan [34]. However, in-depth analysis reveals that even as ADHD research expands into adulthood, longitudinal tracking and intervention exploration for ASD in adult populations remain insufficient. Secondly, diagnostic and epidemiological studies heavily rely on standardized scales and clinical observations, placing excessive emphasis on symptom classification while insufficiently exploring the role of sociocultural differences and family environments in disorder manifestations [35]. Therefore, integrating local cultural elements into future research designs presents a significant challenge.

Cluster #6 "stroke" is the smallest in scale, yet its research themes hold significant clinical and social relevance. Nodes such as "quality of life," "activities of daily living," "generalized anxiety," and "brain injury" are closely interconnected within this cluster. Their co-occurrence reveals that academic research in this field addresses not only physiological rehabilitation but also mental health issues like emotional regulation. This underscores that rehabilitation outcomes should be measured by quality of life, not solely by medical metrics [36]. Consequently, future rehabilitation environment design must transcend biomedical metrics. It should adopt mixed-method approaches, integrating quantitative assessments with qualitative interviews to comprehensively capture patients' authentic lived experiences and social adaptation processes, while fully accounting for cultural variations.

3.1.2. Keyword Burst Analysis

In addition to keyword clustering, advancements in an area can also be shown by the creation of novel keywords. Emergent keywords denote concepts that undergo a substantial rise in frequency over a designated period, indicating changes in research emphasis or the

emergence of trends [37]. Figure 5 illustrates that in the keyword time zone map produced by CiteSpace, blue blocks represent the prolonged duration of a keyword, whereas red blocks signify its abrupt growth phase. The cluster analysis function in CiteSpace was utilised with settings (r[01] = 0.5) and Minimum Duration = 1 to produce a map of the 25 principal keyword clusters, as illustrated in Figure 5. The history can be categorised into three separate phases based on the variations in content and clustering patterns of research hotspots.

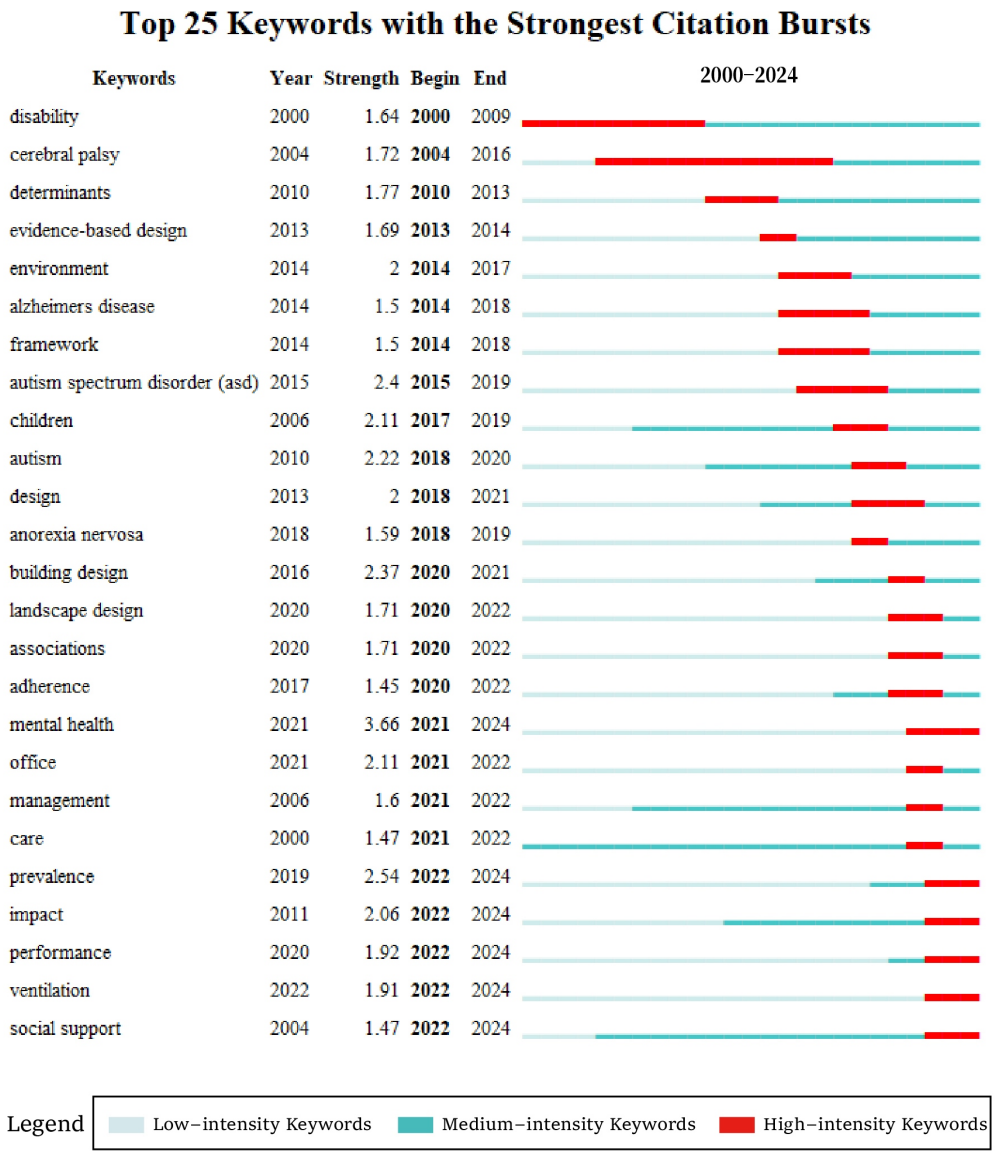

Figure 5. Emergent Word Map of Research Topics Related to Autism Rehabilitation Environments and the Theory of Restorative Environments Generated Using CiteSpace (Top 25 Keywords by Strength) (Generated by the Author).

Keywords from the initial phase (2000–2009) comprised "disability (strength 1.88)," "cerebral palsy (strength 1.7)," "adjustment (strength 1.33)," "adaptation (strength 1.33)," and "depression (strength 1.32)." This suggests that research during this period predominantly uncovered passive adaption dynamics between individuals with impairments and their environments, without distinguishing between disability types or proactively developing solutions. This provided a problem awareness for integrating restorative environmental theory with other disciplines. Mid-phase (2010–2017) keywords included "determinants (strength 1.75)," "developmental disability (strength 1.73)," "brain (strength 1.52)," "en-

vironment (1.79),” and “Alzheimer’s disease (strength 1.47),” indicating a research shift toward neurobiological characteristics and environmental interaction mechanisms. This gradually elevated “environment” from a background variable to an intervention vehicle, advancing the development of restorative environment theory. In the recent phase (2018–2024), keywords such as “design (strength 3.01),” “autism (strength 1.85),” “building design (2.31),” “mental health (3.22),” and “ social support (1.54)” have emerged prominently. This highlights a recent shift in research focus toward environmental design and mental health support, reflecting the growing emphasis on health and sustainability issues in current rehabilitation center environmental design research.

The emergent strengths of “impact” (3.6), “mental health” (3.22), and “prevalence” (2.53) rated as the top three, signifying that the influence of the environment on physical and mental health outcomes has emerged as a focal point in study. Concurrently, an analysis of keyword persistence indicates that “care” (strength 1.79) demonstrates extended duration (2000–2022). While caregiving continues to be a persistent study focus, current findings mostly emphasise sociological, psychological, and individual medical aspects, without enough investigation into its spatial dimensions and design strategies [38]. During the period from 2022 to 2024, “prevalence” (2.53) and “social support” (1.54) surfaced as significant keywords, reflecting an increasing scholarly focus on epidemiological challenges and social support frameworks. The accessibility and equity of rehabilitation resources have emerged as key themes [39].

Overall, the emergent patterns reveal that research trends in environmental design for autism rehabilitation centers converge on three key areas. First, the environment is increasingly viewed as an intervention tool capable of regulating neuro-stress, providing a theoretical foundation for spatial design. Second, design-driven health integration shifts the focus from spatial aesthetics to health science, emphasizing the environment’s active therapeutic functions. Third, urbanization and public health challenges indicate the need to enhance the accessibility of rehabilitation services within limited resources, aligning with SDG 3’s goal of universal health coverage.

3.2. Based on the Core Design Elements of the Restorative Environment Theory

The welfare of children with autism is frequently affected by the conditions of rehabilitation centres. Meeting the practical requirements of rehabilitation environments while improving children’s well-being has emerged as a considerable problem in design practice. This section systematically evaluates research focal points in environmental design for autism rehabilitation centres using a detailed bibliometric analysis and visualisation of term co-occurrence networks. Four fundamental design elements are derived from seven sample research clusters, as seen in the Sankey diagram in Figure 6, which translates research clusters into design elements. Lifespan-Spanning Design originates from Cluster #2 (autism spectrum disorder) and Cluster #3 (attention deficit hyperactivity disorder), highlighting the necessity for rehabilitation centres to cater to the ongoing developmental requirements of preschoolers, school-age children, and teenagers. The design of Family Collaboration and Community Engagement integrates lessons from Cluster #4 (carer) and Cluster #5 (domiciliary care), highlighting the importance of family cooperation and community involvement. This suggests that future designs ought to enhance multi-party coordination among families, carers, and communities. Green and Sustainable Environment Design originates on Cluster #0 (environmental design) discoveries, emphasising the integration of natural lighting, interior ventilation, low-carbon materials, and ecological landscaping to improve indoor air quality and psychological well-being. The design for culturally inclusive and diverse physical-mental development stems from Cluster #1 (burnout) and Cluster #6 (stroke), highlighting the importance of cultural integration in rehabilitation settings and

varied assistance for physical-mental growth. This indicates that designs should integrate local cultural features to strengthen children's cultural identification and social belonging, therefore enhancing quality of life. This framework elucidates the combined functional and emotional requirements of rehabilitation environments while ensuring that each design category is substantiated by solid empirical evidence through systematic translation from cluster analysis to design components, preserving distinct theoretical boundaries during execution.

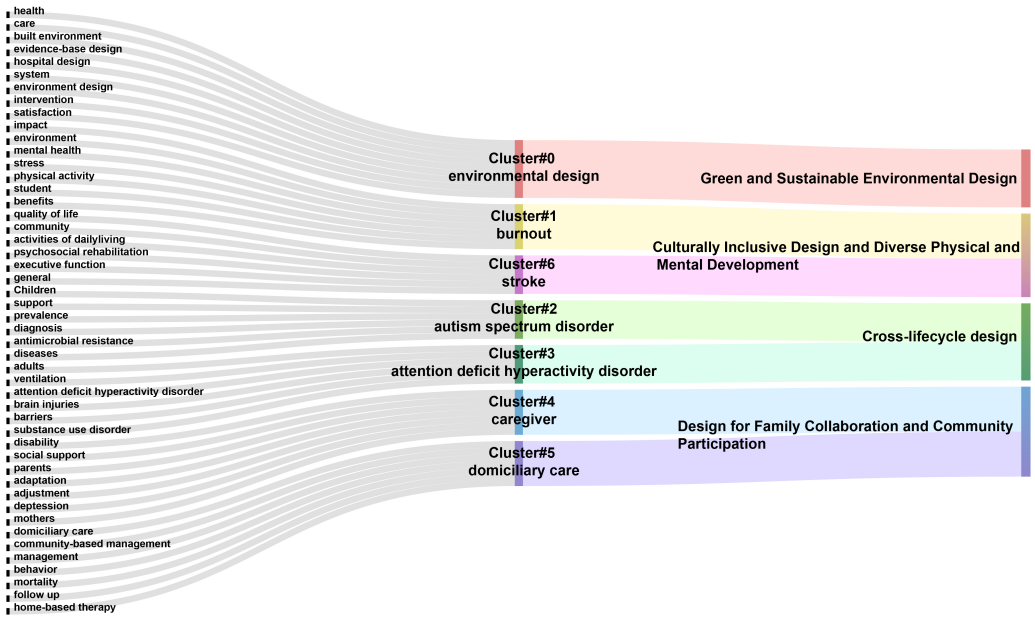

Figure 6. Sankey diagram illustrating the transformation from research topic clusters related to the restorative environment theory and autism rehabilitation environments to design elements (generated by the authors).

3.3. Qualitative Analysis: Multi-Level Case Study

The final database, comprising 24 cases from 16 nations, validates the applicability of the four core aspects across multiple cultural contexts, such as China, the United States, and India, as well as various settings including hospitals, public areas, and mobile implementations. This diversity facilitates comparative examination of intervention design techniques across institutions, cultures, and technologies, rooted in the theory of restorative environments (as shown in Figure 3).

Preliminary observations reveal numerous patterns across classified case studies. Projects under lifecycle-based design primarily focus on spatial design dimensions, including spatial adaptability and scalability. In contrast, designs for family collaboration and community engagement focus on multi-stakeholder coordination, tangibly supporting this goal through specific spatial layouts and environmental elements. Meanwhile, green and sustainable environmental design typically centers on integrating natural elements and healthy building concepts, including natural lighting and ventilation strategies. Culturally inclusive and diverse physical and mental development designs emphasize sensory stimulation and the use of interactive media technologies.

These projects collectively form a diverse yet thematically focused case library centered around key themes such as "rehabilitation environments for children with autism" and "spatial design for restorative environments."

To evaluate the selected cases, this paper employs the concepts of "restorative environmental mechanisms" and "well-being benefits" to assess their impact through

case analysis. This approach enables systematic cross-project comparisons rather than descriptive narratives.

3.3.1. Cross-Lifecycle Design

Lifecycle-spanning design emphasizes the temporal continuity of rehabilitation environments. Through scalable, adjustable spatial and furniture configurations, it supports the progressive growth and rehabilitation of children with autism from preschool through school age to adolescence and adulthood, ensuring seamless transitions and dynamic responses to evolving developmental needs within a single setting [40]. Based on analyses of Cluster #2 and Cluster #3, the rehabilitation needs of individuals with autism are not static but evolve with increasing age and cognitive development. Consequently, rehabilitation settings must exhibit scalability to accommodate growth and adaptation throughout all developmental stages, from early childhood to maturity [41], underscoring the necessity for these environments to dynamically match with user requirements. This research examines six example case studies to further investigate spatial solutions for cross-lifecycle design. Case descriptions are presented in Table 2.

- **Design of Early Intervention by Age Group:** Evidence indicates that design strategies like spatial coding, flexible furniture, and modular layouts effectively meet the rehabilitation and educational requirements of various age demographics, facilitating ongoing adaptability between the environment and its occupants. For instance, Niddrie Autistic School employs a color-coded spatial navigation system that links classrooms, play areas, and transitional corridors through a progressive color scheme. This helps children gradually transition to more complex learning and social settings. Simultaneously, it utilizes progressive challenge spaces to enhance children's sensory and cognitive abilities while controlling the intensity of stimuli. Moreover, Alfreton Park Community Special School offers cohesive assistance for students at all developmental stages by integrating educational, athletic, and therapeutic environments. This design methodology provides substantial benefits in improving the continuity of education, physical exercise, and rehabilitation.
- **Transition Support and Vocational Skills Development Environment:** Medical Care Home and Sweetwater Spectrum Community exemplify practices centred on adolescents and the transition to adulthood. The former promotes psychological well-being by improving security and belonging through domestic designs and a pastoral environment.The latter is on a multipurpose community hub that promotes independent living and social integration through nature-inspired design and modular residential units. Such designs underscore the enhanced significance of rehabilitation in promoting social engagement and vocational education. Nonetheless, limited by spatial resources and community operational expenses, scalable and sustainable operational models have yet to be investigated.

Table 2. Cross-Life-Cycle Design Evaluation Framework (Generated by the Author).

Project	Source	Restorative Environmental Mechanisms	Description	Welfare Benefits	Validation
1.1 Design of Early Intervention by Age Group					
1.1.1	Niddrie Autistic School	Compatibility, Extent	Age-specific color-coded navigation, progressively challenging spaces	Meet the personalized needs and developmental requirements of different age groups	Yes
1.1.2	Sensory Healing Behavioral Health Clinic	Compatibility, Extent	Space and furniture dimensions suitable for all ages	Provide a friendly healthcare experience	No
1.1.3	Alfreton ParkCommunity Special School	Compatibility, Extent	Support for all ages, inclusive classrooms, dedicated spaces for physical activity and therapy	Supporting needs at different stages of development; Meeting requirements for learning, sports, and rehabilitation.	Yes
1.1.4	Mara Bragagnolo puzzle-style furniture	Compatibility, Extent	Modular Multi-Functional Design	Enhancing the Confidence and Social Engagement of Children with Autism	No
1.2 Transition Support and Vocational Skills Development Environment					
1.2.1	Medical Care Home	Being Away, Compatibility, Fascination	Homey layout, rustic atmosphere	Enhance security and belonging, promote mental well-being, strengthen independence and quality of life, support ongoing care and social integration.	Yes
1.2.2	Sweetwater Spectrum Community	Compatibility, Fascination, Being Away, Extent	Family-oriented residential units, multifunctional community centers, and nature-friendly design	Enhance independence and quality of life, foster a sense of belonging, and promote physical and mental well-being.	No

For detailed project numbers, please refer to Figure 3.

3.3.2. Design for Family Collaboration and Community Participation

Designs for family collaboration and community engagement are essential elements of the rehabilitation process, not only ancillary functions of rehabilitation centres. The rehabilitation of children with autism depends not only on interventions from specialised institutions but also necessitates the continuous involvement of family members and the active participation of community resources to establish a comprehensive support network. Studies demonstrate that parental engagement improves adherence to interventions and rehabilitation results, whereas a supportive community atmosphere mitigates social isolation and boosts children's social participation [42]. Consequently, the design of rehabilitation environments should promote parental engagement and a sense of belonging by incorporating features such as parent observation areas, parent-child co-therapy spaces, and family collaboration zones. Utilising community education hubs, public interactive installations, and multi-stakeholder co-creation platforms can enhance public understanding and acceptance of autism, promoting an open, collaborative, and sustainable rehabilitation system. Case descriptions are presented in Table 3.

- **Family Intervention and Parent–Child Co-Therapy Environment:** Establishing temperature controlled sensory regulation rooms, family collaboration zones, and training spaces provides parents with real-time insight into the intervention process [43], thereby strengthening their sense of involvement and trust while promoting adherence to the intervention. Utilising the DaMi and Mi Education Centre as a case study, the incorporation of transparent observation windows and designated family waiting places improves the clarity and understanding of the rehabilitation process. This significantly alleviates parental anxiety, promotes parent–child interaction, and fosters a supportive rehabilitation atmosphere. This design effectively embodies the "Compatibility" and "Fascination" characteristics of the restorative environment theory. It creates spaces that meet children's emotional regulation needs while enhancing parental engagement, thereby strengthening the continuity and effectiveness of rehabilitation interventions.
- **Community Education and Public Participation Node:** Community education functions as a crucial enhancement of rehabilitative environment design, seeking to facilitate the social integration of children with autism through public education, social engagement, and collaborative efforts among several stakeholders. Studies demonstrate that proactive community involvement can diminish feelings of social isolation in families with children diagnosed with autism [44] and improve children's social competencies in practical environments.Consider OTO The Hugging Chair as a case in point. This project employs a multi-stakeholder co-creation approach and sensory-friendly design to provide the public with tactile experiences and possibilities for empathy, ultimately improving society awareness and acceptance of autism.The GoodLife Fitness Family Autism Hub offers rehabilitation and educational services for all age groups, featuring family-oriented facilities and community activity areas. This broadens rehabilitation beyond institutional environments to community settings, enhancing social support networks. These instances collectively illustrate that community education and public participation not only extend the physical limits of rehabilitation but also mobilise societal support structures. This establishes an open, inclusive, and sustainable rehabilitation ecology that promotes children's emotional security, social competencies, and engagement in daily activities.

Table 3. Design Evaluation Framework for Family Collaboration and Community Engagement (Generated by the authors).

Project	Source	Restorative Environmental Mechanisms	Description	Welfare Benefits	Validation
2.1 Family Intervention and Parent-Child Co-Therapy Environment					
2.1.1	Autism Sanatorium inIran	Compatibility, Extent	Public Education and Training Area, Open Landscape Space	Enhance social support, improve quality of life, meet educational and charitable needs, and provide ongoing learning opportunities.	Yes
2.1.2	Sabara Children's Hospital	Being Away, Compatibility, Fascination	Thermostatically Controlled Sensory Regulation Room, Family Collaboration and Shared Area, Pet Visitation Space	Promote sensory regulation and emotional stability, and promote social support systems.	Yes
2.1.3	DaMi and Mi Education Center	Compatibility, Fascination	Multi-angle visibility design, family waiting observation area	Enhance the transparency and supportiveness of the intervention process to ensure continuity in learning and social experiences.	Yes
2.2 Community Education and Public Participation Node					
2.2.1	OTO The hugging chair made for people with autism	Being Away, Compatibility	Sensory Shelter Device, Multi-Party Collaborative Design Process	Alleviate sensory stress, enhance a sense of security, and promote social integration.	Yes
2.2.2	GoodLife Fitness Family Autism Hub	Compatibility, Extent	Services for all ages, family-friendly design	Continuum of care, enhanced family support, overall well-being, social integration.	Yes
2.2.3	TOUCH friends–Social Intervention Interactive Product Design for Children with Autism	Compatibility, Fascination	Online–offline integrated platform, multi-scenario linkage	Enhance social skills, ensure continuity of intervention, and strengthen social integration and community support.	Yes

For detailed project numbers, please refer to Figure 3.

3.3.3. Green and Sustainable Environmental Design

Green and sustainable environmental design embodies energy efficiency and ecological principles while actively enhancing health and well-being in rehabilitative environments. Research demonstrates that including green building and sustainable design concepts in the development of rehabilitation centres improves air quality, functionality, and comfort, while also promoting a safe, healthy, and stimulating rehabilitation environment. Utilising natural lighting, landscape integration, low-carbon materials, and adjustable ventilation systems, rehabilitation rooms can enhance air quality, temperature, humidity, and physiological comfort. Psychologically, they reduce tension and sensory stress, augment children's inquisitive interest and learning engagement, establishing a practical foundation for future ideas of healthy and sustainable spatial solutions.Case descriptions are presented in Table 4.

- **Integration of Natural Lighting and Open Views:** By integrating natural lighting, ventilation, ecological landscaping, and low-carbon materials, indoor air quality is improved, sensory stress is reduced, and psychological comfort is enhanced. Against this backdrop, an increasing number of rehabilitation centers are incorporating green strategies into their architectural and outdoor environment designs. For instance, Rebecca Horn's Creating a Multifunctional Space for Students with Autism utilizes spacious corridors, large skylights with louvered shutters, and sensory-friendly zones to introduce natural light and expansive views. This approach helps reduce anxiety and sensory overload while stimulating motivation for learning and social interaction.
- **Artificial Low-Stimulus Natural Environment:** Practice has demonstrated that low-stimulus, nature-friendly rehabilitation spaces can effectively alleviate sensory overload [45] and emotional tension, thereby enhancing intervention compliance and rehabilitation efficiency. Low-stimulus natural environment methods, grounded on this basis, exhibit considerable promise in alleviating sensory overload and anxiety in children with autism through the incorporation of muted colour schemes, adaptable lighting systems, and high-performance soundproofing materials [46]. Taking FlvSolo Rehabilitation Medical Center as an example, research indicates that its integrated application of soft color schemes, dimmable lighting, and soundproof ceilings effectively reduces sensory overload. This helps patients maintain emotional stability during rehabilitation while enhancing the continuity and comfort of interventions.

3.3.4. Culturally Inclusive Design and Diverse Physical and Mental Development

Cultural inclusion and diversified psychophysical development are essential aspects of restorative environmental design. The essence involves creating a rehabilitation environment that is culturally significant and stimulates sensory systems through the integration of local cultural symbols, the introduction of multisensory stimuli, and the incorporation of emotional support technologies.Research indicates that integrating cultural elements enhances identity recognition and security among children with autism, reducing psychological resistance to unfamiliar settings. Multisensory interactive experiences help improve attention deficits, promote emotional regulation, and increase willingness for social interaction. Concurrently, emotional support spaces provide children with controlled, low-pressure environments for expression and learning, alleviating anxiety and boosting rehabilitation engagement. Case descriptions are presented in Table 5.

Table 4. Green and Sustainable Environmental Design Evaluation Framework (Generated by the authors).

Project	Source	Restorative Environmental Mechanisms	Description	Welfare Benefits	Validation
3.1 Integration of Natural Lighting and Open Views					
3.1.1	Rebecca Horn Creating a welcoming, multifunctional space for students with autism	Extent, Fascination	Broad corridors, ample natural light (shutters), adjustable lighting, emotional buffer zones	Reduce anxiety and sensory overload, promote active participation in social interactions and learning.	Yes
3.1.2	The Center of Excellence–Sensory	Extent, Fascination	Sensory Garden, Open Courtyard, Play of Light and Shadow, Immersive Experience	Enhance attention recovery, alleviate sensory fatigue, and boost children's interest in exploration.	No
3.1.3	Evr-Architecten, Callebaut Architecten	Extent, Compatibility	Natural ventilation, green courtyards, thermal insulation and ventilation, rainwater harvesting	Enhance comfort and reduce energy consumption	Yes
3.2 Artificial Low-Stimulus Natural Environment					
3.2.1	FIvSolo Rehabilitation Center	Compatibility, Being Away	Soft color palette, adjustable lighting, soundproof ceiling, functional zoning	Reduce sensory stress during the rehabilitation process	No
3.2.2	Snoezelen Multi-Sensory Environment	Fascination, Compatibility	Using bubble columns, fiber optic beams, soft projections, and light music to create a controlled sensory stimulation environment.	Alleviate anxiety and emotional outbursts, enhance autonomy and engagement, and promote social interaction	Yes
3.2.3	Day Center for Young People with Autism in Debes	Extent	Semi-transparent facades, natural light penetration, low-maintenance greenery	Improve mood, reduce operating costs	Yes

For detailed project numbers, please refer to Figure 3.

Table 5. Culturally Inclusive and Diverse Physical and Mental Development Design Evaluation Framework.(Generated by the authors).

Project	Source	Restorative Environmental Mechanisms	Description	Welfare Benefits	Validation
4.1 Local Cultural Symbols and Narrative Practices					
4.1.1	Sai Kirupa Special School	Extent, Compatibility	Courtyard corridors and cultural integration; Ventilation, natural light, and clear circulation paths.	Promoting children's sense of belonging to local culture	Yes
4.1.2	Starkids	Fascination,Being Away	Utilizing EEG biofeedback; Visualized character interactions, Focus training, real-time adjustment	Improve attention deficits and enhance learning and rehabilitation compliance	No
4.1.3	KNOP	Compatibility, Fascination	Modular assembly; collaborative interactive creative storytelling	Enhance social interaction and collaboration skills, improve emotional stability	No
4.2 Multifaceted Interaction and Emotional Support					
4.2.1	Eora Emotional Robot	Compatibility,Being Away	Emotion Recognition; Immediate Comfort Intelligent Companionship; Dual-Scenario Use	Reduce anxiety levels and enhance willingness to socialize	No
4.2.2	Spectrum Interactive Toy System	Fascination, Extent	Modular Toy App Guidance (Task-Driven, Sensory Coordination, Focus Guidance, Social Promotion)	Enhance attention and task focus, strengthen peer collaboration and social interaction	No
4.2.3	Story Multisensory Narrative Therapy Suite	Fascination, Compatibility	Multi-sensory interaction, role-playing, emotional release, rule learning	Enhance language expression and imagination,improve emotional regulation and social adaptation	No

For detailed project numbers, please refer to Figure 3.

- **Local Cultural Symbols and Narrative Practices:** By integrating local cultural symbols, narrative elements, and contextual spaces [47] into rehabilitation environments, children with autism spectrum disorder can establish psychological safety and cultural identity, thereby effectively enhancing intervention acceptance and participation [48]. Sai Kirupa Special School employs courtyard pathways, indigenous flora, and natural illumination to establish a rehabilitative environment that harmonises openness with local attributes. This design facilitates cultural continuity and fosters a sense of belonging for youngsters during everyday educational and rehabilitative activities. The KNOP modular assembly method utilises modular construction and collaborative storytelling to facilitate children's cooperation, collaboration, and communication in the creation of narrative plots. This method cultivates social skills while simultaneously improving emotional management and situational awareness.
- **Multifaceted Interaction and Emotional Support:** Multimodal interactive and emotional support designs utilise many technologies to offer children secure avenues for emotional expression and contextual learning experiences. For instance, the Eora emotional robot utilizes emotion recognition and instant companionship to reduce anxiety levels and stimulate social engagement. The Spectrum interactive toy system enhances children's task focus and peer interaction abilities through modular app guidance and sensory collaboration. These cases demonstrate that culturally and multi-sensory designs can effectively activate children's cognitive and emotional systems, promoting attention restoration and social skill development. This embodies the "Fascination" and "Being Away" characteristics within restorative environment theory.

4. Environmental Design Strategies for Chinese Autism Rehabilitation Centers Based on Research Findings

4.1. Environmental Design Strategies for Cross-Lifecycle Applications

The rehabilitation requirements of individuals with autism spectrum condition are fluid, changing with age, cognitive advancement, and heightened social engagement. Environmental design must be scalable and dynamically adjustable to facilitate the continuum of rehabilitation from early intervention to adult social integration. Preschool-aged children, possessing very sensitive sensory systems, may experience emotional outbursts and avoidance behaviors due to excessive stimulation [49]. Spaces must reduce cognitive burden by providing clear, uncluttered circulation paths and visual interfaces, hence preventing overstimulation. Creating adaptable environments, such as tranquil chambers and gentle illumination, mitigates sensory overload [50]. For school-age children, environmental design should support attention development, energy release, and group interaction through parallel learning and social zones alongside open activity spaces, fostering synchronized cognitive, emotional, and behavioral growth. Upon entering adolescence, rehabilitation environments should prioritize simulating real-world social scenarios. By establishing functional zones like vocational training areas and life skills zones, and utilizing movable partitions and modular furniture to enable flexible multi-scenario transitions, space utilization and environmental adaptation efficiency are maximized [51]. Taking the design of Beijing FlySolo Children's Rehabilitation Center as an example, the project employs a movable partition system (such as aluminum folding partitions) to achieve flexible spatial transformation. This approach increases the utilization rate of multifunctional scenarios by 35% while reducing environmental adjustment costs.

Through a multi-stage, compatibility spatial organization strategy, the rehabilitation environment dynamically aligns with the functional needs of individuals with autism at different developmental stages. This approach enhances spatial efficiency and intervention continuity while supporting rehabilitation interventions, interest exploration, and

emotional regulation, thereby strengthening the environment's therapeutic efficacy and ensuring sustainable space utilization.

4.2. Environmental Design Strategies Aimed at Fostering Family Collaboration and Community Engagement

The rehabilitation of children with autism relies not only on treatment from specialized institutions but also on sustained family involvement and coordinated support from community resources. Consequently, rehabilitation institutes must to evolve from singular treatment facilities into collaborative support networks that engage families and communities. Facilities should provide designated areas for parental observation, co-therapy rooms for parents and children, and multi-angled waiting zones. This allows parents to observe interventions in real time and participate in rehabilitation activities, thereby alleviating anxiety [52], enhancing trust, and improving cooperation. The case of the DaMi and XiaoMi Education Center demonstrates that introducing visual observation windows and multi-angle waiting spaces significantly increases parental involvement and intervention transparency. At the community level, public education galleries, sensory interactive installations, and multi-stakeholder collaborative activities should be implemented to enhance public awareness and acceptance of autism [53]. For instance, the OTO Hugging Chair, developed through multi-stakeholder collaboration and featuring tactile-friendly design, allows the public to experience the sensory world of children with autism, fostering social empathy. Additionally, multi-tiered community rehabilitation resources—such as therapeutic gardens, parent-child education courses, and community volunteer companionship programs—can transform rehabilitation centers into open, interactive community hubs. Through this coordinated family-institution-community strategy, rehabilitation centers transcend traditional medical boundaries to establish a multi-level support system encompassing family accompaniment, community engagement, and professional intervention.

The synergistic merging of "Fascination" and "Compatibility" renders rehabilitation rooms both emotionally appealing and functionally customized to individual requirements. This approach not only fosters sustained participation from families and communities but also ensures dynamic alignment between intervention processes and environmental characteristics. Consequently, it significantly enhances recovery outcomes and improves the long-term sustainability of space utilization.

4.3. Environmental Design Strategies for Green and Sustainable Design

Green and sustainable design is not merely a technical means for building energy efficiency, but also a core pathway for promoting health in rehabilitation environments. The aims encompass enhancing air quality, alleviating sensory tension, offering psychological relaxation, and attaining long-term operational sustainability and environmental friendliness. Initially, enhancing spatial lighting conditions via natural daylighting, courtyard infiltration, and light–shadow modulation [54] promotes landscape accessibility and permeability, hence augmenting psychological satisfaction and exploratory engagement. The Rebecca Horn project illustrates that the incorporation of natural light and vegetation markedly alleviates anxiety in children with autism, fostering emotional equilibrium and social engagement. Secondly, a low-stimulus sensory environment is established by the use of muted hues, adaptable lighting systems, and acoustically efficient soundproof ceilings. This aids in stabilizing children's emotions, mitigating sensory overload, and enhancing compliance and consistency in rehabilitative interventions [55]. Furthermore, the integration of indoor vertical greening systems, such as living walls, not only boosts air quality and promotes the diffuse reflection of natural light but also offers soothing visual focal points and chances for engagement with nature. This fosters a serene yet dynamic atmosphere that aids children's emotional self-regulation.

By employing the spatial organization logic of "Fascination" and "Compatibility," the rehabilitation environment is designed to both stimulate children's exploratory curiosity and foster a connection with nature, while dynamically responding to their psychological and physiological needs. This approach ultimately achieves the dual goals of highly effective rehabilitation interventions and an environment with enduring restorative power.

4.4. Environmental Design Strategies Aimed at Cultural Inclusivity and Diverse Physical and Mental Development

The design of rehabilitation centers that incorporates cultural inclusivity and multisensory stimulation enhances autistic children's sense of security and cultural identity while also fostering their social motivation and emotional expression, thereby promoting holistic physical and mental development [56]. Rehabilitation center design should consider local culture, family culture, and the specific needs of autistic children. In practical design, local cultural [57] symbols can be integrated into wall decorations, soft furnishings, and interactive installations—such as traditional geometric patterns, ethnic color palettes, and themes from indigenous folklore. This enables children to get stability and acknowledgment through familiar cultural symbols.Establishing designated spaces such as story corners, music stations [58], or tactile puzzle zones allows children to interact with cultural elements through many sensory modalities—auditory, tactile, and visual—thereby enhancing their desire for learning and communication. Empirical research reveals that the Gokh team, by monitoring over 200 individuals with autism, found that cultural identification markedly improves social motivation. Approximately 40% of respondents reported improved social integration due to recognizing the cultural attributes of "neurodiversity," with their psychological safety positively correlated with identity formation [59]. Secondly, multi-sensory interactions [60] and emotional support devices should be fully leveraged to stimulate exploratory drive and emotional regulation capabilities. Research on the Spectrum interactive toy system abroad indicates that such multisensory interactive designs can significantly enhance children's attention span and peer cooperation rates while reducing the frequency of repetitive behaviors [61].

The rehabilitation environment employs spatial arrangement focused on "Fascination" and "Being Away" to engage children with various cultural and sensory elements, promoting active engagement. Concurrently, varied experiential environments enable children to momentarily disengage from everyday stressors, immersing them in a therapeutic situation. This method amplifies the pleasure and emotional management advantages of therapeutic activities while promoting enduring social integration.

5. Limitations

This review acknowledges several methodological and practical limitations that may influence our findings. Although the paper systematically identified research hotspots in environmental design for autism rehabilitation centers using bibliometric analysis and visual clustering methods based on the Web of Science database, and further distilled four core design elements, several limitations warrant clarification. First, the findings rely to a significant extent on bibliometric analysis. While this method efficiently reveals research themes and evolutionary trends, it carries risks of oversimplification and neglecting practical contexts. For instance, bibliometric analysis primarily reflects consensus among published works, potentially overlooking emerging research directions under exploration and small-scale innovative design practices. This may result in lagging or incomplete strategy refinement.

Secondly, the strategies proposed in this paper are primarily based on a comprehensive analysis of literature findings and representative case studies, resulting in a relatively weak

empirical foundation. This may lead to variations in the strategies' applicability across different cultural contexts or resource conditions. Subsequent research should validate and iterate these strategies through multi-center comparative experiments, participatory design workshops, and longitudinal tracking evaluations.

The limitations in case selection warrant consideration. The reviewed studies primarily feature completed implementation cases. Future research may address these limitations by incorporating more prospective conceptual designs and emerging theoretical frameworks, combined with multi-source literature and empirical validation. It should be noted that the data used in this study originated solely from the Web of Science Core Collection. Future research could further incorporate other databases such as PubMed, Scopus, and ProQuest Health & Medicine to comprehensively explore the evidence base for restorative environment theory in the design of autism rehabilitation centers, thereby avoiding potential outcome biases associated with a single data source.

6. Conclusions

This review is based on the Web of Science database. It combines macro-level bibliometric analysis with micro-level content analysis to systematically explore the current status and knowledge structure of the theory of restorative environment in autism rehabilitation centers. Focusing on the background, hot topics, high-frequency terms, and their integration with SDG 3 ("Ensure healthy lifestyles"), this study examines implementation challenges in the Chinese context, proposes design strategies, and provides new perspectives and practical guidance for the sustainable development of autism rehabilitation centers. The main contributions are as follows:

Theoretically, this study's novelty goes beyond systematic literature review and knowledge map creation. It displays two crucial aspects: Theory integration and innovation first. This paper systematically integrates Restorative Environment Theory (RET) with SDG3, turning RET from a psychological framework focused on natural healing and attention restoration into a multidisciplinary theoretical tool for autism rehabilitation center environmental design. RET takes design beyond physical space modification to emphasize psychological rehabilitation, emotional support, and social engagement. A more inclusive and multi-layered framework provides a new theoretical perspective for autism rehabilitation space research.Second, interdisciplinary integration in methodology. This review adopts a research approach combining macro-level bibliometric analysis with micro-level qualitative analysis. It not only reveals research hotspots and knowledge structures within the field but also distills design insights with cultural adaptability and lifecycle characteristics through comparative case studies and content analysis. This interdisciplinary integration enhances the explanatory power and innovation of the research, providing valuable reference for subsequent studies.

In terms of practical application, unlike previous literature reviews on autism-friendly design or restorative environment theory, this paper not only systematically synthesizes existing research but also contributes new knowledge across three dimensions: theory, methodology, and practice. It proposes four key strategies: lifecycle-spanning design, family-community collaboration, green sustainability, and cultural inclusivity. These strategies offer practical responses to real-world challenges such as limited resources, cultural diversity, and equity gaps, demonstrating both operational feasibility and potential for broader implementation.

Preliminary research has found the following:

(1) The design of autism rehabilitation centers has a multidimensional impact on patients. This includes spatial aspects, such as age-specific functional diversity and adaptation to comorbid characteristics; psychological aspects, such as caregiver stress levels; physical

environmental factors, such as air and lighting conditions; and cultural diversity, which can also affect patients' mental health and well-being.

(2) The restorative environment theory provides a theoretical basis for the design of rehabilitation center environments. By analyzing four core characteristics—being away, extent, fascination, and compatibility—it is possible to comprehensively assess the impact of rehabilitation center design on patient well-being.

Therefore, future design should place greater emphasis on aspects related to the rehabilitation environment for children with autism, further exploring the applicability and effectiveness of these strategies across different cultural contexts. Additionally, through international collaboration and exchange, drawing on the advanced experiences in autism rehabilitation environment design from leading countries can better promote the high-quality development of autism rehabilitation environments in China. It is important to note that the data used in this study is solely sourced from the WOS Core Collection. Future research could expand to include other databases such as PubMed, Scopus, and ProQuest Health & Medicine to comprehensively explore the evidence-based foundations of restorative environment theory in the design of autism rehabilitation centers.

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