Research Article

Environmental determinants of family resilience in pediatric leukemia: A longitudinal mixed-methods study

Xiao Liu[1,2], Paramjit Singh Jamir Singh[1,*]

[1]Department of Social Work, School of Social Sciences, Universiti Sains Malaysia, Minden, Penang, 11800, Malaysia

[2]Dongfang College, Shandong University of Finance and Economics, Taian, Shandong, 271000, China

* Corresponding author: Paramjit Singh Jamir Singh, paramjit@usm.my

ABSTRACT

This study explores from the perspective of the social ecosystem how multi-level environmental factors shape the psychosocial adaptation process of families with children diagnosed with leukemia in China. Employing a longitudinal mixed-methods design, the study utilized tracking data from the China Family Panel Studies (CFPS) from 2014 to 2020, including 187 observation points from 58 families. The analysis integrated narrative analysis, thematic analysis, and growth curve modeling to examine family adaptation trajectories and their environmental determinants. The results identified three environment-driven adaptation trajectories: rapid recovery type (28.1%), gradual adaptation type (51.7%), and persistent predicament type (20.2%). Medical insurance type emerged as the strongest environmental predictor, explaining 31.5% of the variance in depression trajectories (β=-3.45, p<0.001), with families covered by employee medical insurance demonstrating psychological recovery speeds 2.3 times faster than those under the New Rural Cooperative Medical Scheme. Environmental factors collectively explained 67% of the variance in family adaptation outcomes, revealing the systematic effects of medical environment, policy environment, community environment, and cultural environment. The research integrates Bronfenbrenner's ecosystem theory with Walsh's family resilience model to construct an integrated framework of "Family Resilience in the Environment." The findings indicate that unequal distribution of environmental resources is the fundamental cause of family adaptation differentiation. Multi-level environmental interventions are urgently needed to promote psychosocial adaptation and health equity for families affected by childhood leukemia, including increasing medical insurance reimbursement rates, optimizing the medical environment, building community support networks, and promoting cultural de-stigmatization.

Keywords: childhood leukemia; family resilience; environmental factors; psychosocial adaptation; mixed-methods research; ecological systems theory

1. Introduction

Childhood leukemia, as the most common malignant tumor in children, has an annual incidence rate of approximately 4-6 per 100,000 in China, though recent studies suggest variations across regions[1]. With the advancement of medical technology, the success rate of treatment has significantly improved to 70-80% in

many medical centers[2], but the long treatment cycle (2-3 years) poses multi-level environmental pressure challenges to families. From the perspective of the social ecosystem, the adaptation process of families with childhood leukemia is embedded in a complex environmental system[3]. At the medical environment level, the long-term isolation in sterile wards (with an average of 3 to 6 months), unfamiliar medical equipment and invasive procedures have a strong psychological impact on families[4]. Approximately 43% of families need to seek medical treatment in different cities. The frequent trips to hospitals (an average of 8 to 12 times per month) have led to changes in the spatial environment, intensifying the sense of loss of control and identity crisis within families[5].

At the level of the community social environment, families are confronted with the dual tension of support and stigma. On the one hand, neighborhood mutual assistance networks, patient communities and relatives' resources provide important support for families[6]; On the other hand, the risk of social isolation caused by misunderstandings about the contagiousness of diseases and sympathetic eyes cannot be ignored[7]. The urban-rural disparity further amplifies this environmental effect - although urban families have higher anonymity and more support services, rural families are constrained by the culture of face, and the phenomenon of stigmatization is even more serious[8].

The inequality of the policy and institutional environment is the key factor for the significant disparity in the economic burden of families. The medical insurance for urban employees can reimburse 70-80%, while the medical insurance for urban and rural residents and the New Rural Cooperative Medical Scheme can only reimburse 50-60%, resulting in a disparity of 58,000 to 216,000 yuan in the annual out-of-pocket expenses among different families[9]. In addition, the complex reimbursement process for medical treatment in a different location and insufficient support during the rehabilitation period, among other policy gaps, have further exacerbated the family's predicament[10]. The cultural environment, as a macro system, profoundly influences the coping patterns of families. Chinese collectivist culture has promoted the mobilization of family resources, but the tradition of "reporting good news but not bad" caused by the self-sacrifice of grandparents driven by filial piety ethics and the culture of face has also brought heavy psychological burdens to family members[11].

Bronfenbrenner's ecological systems theory characterizes the environment as a structure of different concentric spheres influencing human development. The core idea is that the layers of environment influence the individual. Moreover, the individual also influences the environments surrounding him or her. The school, home, and other environments are key to the child's development through interactions[12]. The present study was guided by the theoretical lens in several ways. When formulating the research question, the theory drew attention to the relative contributions of different levels of the environment, from the medical setting to policy level, to family adaptation. The microsystem concept guided the focus on immediate family-hospital interactions, including ward ambiance and health worker interactions. A mesosystem framework guided analysis of the relations between family systems and external support structures, such as patient communities and neighborhood resources. The exosystem perspective has informed the investigation of institutional elements that indirectly influence families, especially medical insurance policies and reimbursement mechanisms. The family's values and beliefs shape their coping patterns, and these beliefs don't only come from the family. The Walsh family resilience model supports the ecological perspective because it shows how families internally process challenges[13]. The Family Resilience Model emphasizes three important domains. These are belief systems, organizational patterns and communication processes. Consequently, families create meaning from adversities and mobilize resources to be flexible and communicate emotions and problems. The combination of these two theories shows us more than either can do on its own. We see that Bronfenbrenner's framework shows the environment families must apply Walsh's model processes to

get through the environments. The research design was directly informed by this theory. The quantitative component aims to assess the predictive power of environmental variables conceptualized at each ecological level. The qualitative component investigates how families make sense of the situation and use this knowledge to adapt. The thought in findings is based on same theories, such that difference within the environment is interpreted through ecology theory of social behavior while family coping is narrative through resilience theory.

There are obvious gaps in the current research. International research mainly focuses on the internal dynamics of families, while the examination of environmental factors is relatively scattered[14]. Relevant research in China mainly focuses on the medical perspective, concentrating on the individual psychology of children patients or the burden of caregivers, lacking studies that analyze the family as a whole within a multi-level environmental system[15]. Especially under the background of China's special cultural environment and medical system, the resilience construction process of environment-family interaction urgently needs in-depth exploration.

The present study integrates Bronfenbrenner's ecological systems theory with Walsh's family resilience model to systematically explore the adaptation process of families with childhood leukemia in China. The research addresses three interrelated objectives: to identify distinct family adaptation trajectories and their environmental determinants, to examine how families actively construct resilience through interactions with multi-level environmental systems, and to elucidate mechanisms through which environmental resources and constraints shape psychological outcomes. These objectives correspond to specific theoretical propositions— the ecological framework predicts that environmental factors at different system levels will demonstrate differential predictive power, while the resilience model suggests that families with similar environmental exposures may achieve different outcomes depending on their internal adaptive capacities. The mixed-methods design was chosen to test these propositions: growth curve modeling quantifies environmental predictors across trajectories, while narrative and thematic analyses reveal processes through which families negotiate environmental challenges. The study contributes to theoretical development by constructing an integrated "Family Resilience in the Environment" framework bridging macro-level environmental determinants with micro-level family processes, providing an evidence-based foundation for optimizing medical environments, building community support networks, and improving medical security policies in China.

2. Data and methods

2.1. Research design

The present study employs a convergent parallel mixed-methods design (QUAL+ QUAN), following Creswell and Plano Clark (2018), to explore family resilience construction within a multi-level environmental system. The rationale for this design stems from the complementary strengths of both approaches: quantitative methods enable identification of significant environmental predictors and classification of adaptation trajectories, testing propositions derived from Bronfenbrenner's ecological systems theory; qualitative methods provide depth of understanding regarding how families interpret and transform their environmental contexts, illuminating mechanisms underlying Walsh's family resilience model. The integration strategy operates at multiple levels: at the design level, data collection occurred concurrently across CFPS survey waves (2014-2020); at the analysis level, quantitative trajectory classifications informed purposive sampling for qualitative analysis, while qualitative themes guided operationalization of quantitative variables; at the interpretation level, findings from both strands are synthesized in the discussion

section. This convergent design maximizes validity through methodological triangulation while maintaining the distinctive contributions of each analytical tradition.

The qualitative component employs narrative analysis and thematic analysis. Narrative analysis focuses on how families endow disease experiences with meaning through narration, revealing the multiple roles of the environment in family narratives. Thematic analysis combines deductive coding (environmental hierarchy based on Bronfenbrenner's ecosystem theory) and inductive coding (new themes emerging from data) to systematically identify environmental themes across families. Two researchers independently coded the qualitative data and reached consensus through negotiation (Kappa>0.75). The quantitative component utilizes growth curve modeling to analyze longitudinal data across 187 observation points from 58 families, examining how environmental factors predict family adaptation trajectories over time. This approach enables the identification of distinct adaptation patterns and quantification of the predictive power of multi-level environmental variables. The theoretical framework integrates Bronfenbrenner's social ecosystem theory, which guides multi-level analysis from microsystems to macrosystems, with Walsh's family resilience model to understand the internal processes of the family. The environmental stress-resource-adaptation model is employed to clarify the dynamic balance mechanism. The research emphasizes an integrated perspective of environment-psychology interaction, regarding the family as an active subject embedded in a multi-level environment, where the environment serves as both a source of stress and a resource pool. By focusing on both the family as a whole and the interaction between the family-environment system, and taking into account the depth of case narrative and cross-case comparison, the study provides insights into family resilience in the context of Chinese culture.

The quality of mixed-methods integration was evaluated by set criteria for convergent designs. The qualitative themes were quantified (frequency counts for each coded segments) and the quantitative findings were qualified (narrative interpretation of statistical patterns). The analysis utilized joint display tables showing side-by-side comparison of quantitative results with qualitative themes to create integration. The overall interpretation of the results incorporated the two types of data. The quantitative evidence offered scope and generalizability while the qualitative evidence offered depth and a mechanistic understanding. We regarded possible contradictions between strands as opportunities for inquiry and not as methodological problems in accordance with the dialectical position advocated in mixed-methods literature.

2.2. Data source

This study utilized the data from 2014 to 2020 of the China Family Panel Studies (CFPS) (4 waves). CFPS was implemented by the China Social Science Survey Center of Peking University, covering 25 provinces/municipalities/autonomous regions. The sample included approximately 16,000 households and over 40,000 individuals, making it nationally representative[16].

The CFPS dataset fully measures the multi-level environment in which families are located and is highly suitable for the environment-psychology perspective of this study. The data contains a wealth of environmental variables: medical environment (type of medical insurance, distance to medical treatment, medical accessibility), community environment (urban-rural type, community support network, neighborhood relationship), policy environment (medical insurance reimbursement ratio, assistance acquisition situation), and cultural environment indicators (value scale, family decision-making model). CFPS data have been widely applied in the research of medical reform, health inequality and the effects of medical insurance policies[17,18], demonstrating its effectiveness in health-related environment studies. Particularly important is that CFPS open-ended questions (such as "The biggest changes in the family over the past year", "How to cope with the changes", "What kind of help was received") can extract narrative texts

of environmental coping strategies, providing materials for qualitative analysis. This study adheres to the CFPS data usage Agreement, and data acquisition has been processed through the official platform application procedure.

The identification of families affected by childhood leukemia from the CFPS dataset represents a unique analytical opportunity. While childhood leukemia is relatively rare (annual incidence of approximately 4-6 per 100,000 children), the large-scale and longitudinal nature of CFPS enables the identification of a sufficient subsample for analysis. The 58 families included in this study were identified through systematic screening across all survey waves from 2014 to 2020, leveraging both structured health module data (ICD-10 codes) and open-ended narrative questions that captured disease experiences. Although this represents a small proportion of the overall CFPS sample, it provides valuable insights into family adaptation processes while maintaining the methodological rigor of nationally representative survey data. The geographic distribution of these families across 19 provinces ensures diverse environmental contexts, enhancing the study's ecological validity.

The 187 observation points represent the total number of family-level data records collected across four survey waves (2014, 2016, 2018, and 2020). The temporal distribution of these observations reflects the panel nature of CFPS data collection: 58 families were identified as meeting inclusion criteria at baseline, with each family contributing between 2 and 4 observation points depending on their participation across survey waves. The distribution across waves was as follows: 58 observations in 2014 (baseline for most families), 52 observations in 2016, 46 observations in 2018, and 31 observations in 2020. The attrition across waves primarily resulted from family relocation, survey non-response, and in some cases, the death of the child patient. Each observation point captures both structured quantitative data (demographic characteristics, environmental variables, psychological scales) and unstructured qualitative data (responses to open-ended questions regarding family experiences, coping strategies, and environmental interactions). The longitudinal nature of these observations enables the modeling of adaptation trajectories over time and the examination of how environmental factors predict changes in psychological outcomes across the 6-year study period. The average number of observation points per family was 3.2 (SD=0.9), with 72.4% of families contributing three or more observation points, thereby providing sufficient within-family variation for growth curve modeling.

2.3. Sample selection

This study employed a multi-step screening program to identify target families from CFPS data. The inclusion criteria include: (1) A child aged 0-18 in the family has been diagnosed with leukemia, and the identification is made by explicitly mentioning "leukemia", "blood cancer", etc. through the disease code of the health module (ICD-10: C91-C95) or open-ended questions; (2) Participate in at least two waves of surveys (any two years from 2014 to 2020) to ensure there is tracking data to observe environmental changes; (3) The primary caregiver completed the adult questionnaire, including the mental health scale and open-ended questions; (4) Open-ended questions should have substantive answers (50 words or more, and the content should involve disease response or environmental interaction); (5) At least six months after diagnosis, ensure that the adaptation stage is entered; (6) The absence rate of key environmental variables (such as medical insurance type, urban-rural type, community type, etc.) is less than 20%.

The exclusion criteria are: the child has died or been lost to follow-up, the data quality is marked as "unreliable", the diagnosis time cannot be clearly defined, and open-ended questions are blank or invalid. After screening, **58 families** were finally included, with a total of **187 observation points** (across 4 survey waves from 2014 to 2020), reaching the theoretical saturation of qualitative research.

2.4. Data analysis methods

This study employs a parallel mixed-methods analytical strategy in which qualitative and quantitative analyses are conducted independently and then integrated to provide complementary insights into family adaptation processes. Qualitative analysis reveals the mechanisms and meanings of environmental adaptation, while quantitative analysis quantifies the predictive effects of environmental factors and identifies distinct adaptation trajectories. The qualitative component addresses three core research themes: how families construct meaning around environmental challenges, what adaptive strategies families develop to navigate multi-level environmental systems, and how environmental resources shape family resilience narratives over time. Data collection instruments consisted of CFPS open-ended survey items, including: "What have been the biggest changes in your family over the past year?" "How has your family coped with these changes?" "What kind of help or support has your family received?" and "What challenges or difficulties has your family encountered?" These items generated narrative texts averaging 50-200 words per response, yielding 187 narrative segments for analysis. The data analysis strategy integrated narrative analysis following Labov's (1972) framework, which identifies narrative elements including orientation, complication, evaluation, resolution, and coda, with thematic analysis following Braun and Clarke's (2006) six-phase procedure. The coding framework combined deductive codes derived from Bronfenbrenner's ecological systems theory (microsystem, mesosystem, exosystem, macrosystem) with inductive codes emerging from data (such as "stigma management," "treatment gamification," and "policy navigation"). The codebook included operational definitions, inclusion and exclusion criteria, and representative examples. Two researchers independently coded all segments using NVivo 14, achieving inter-rater reliability of Kappa=0.78, with discrepancies resolved through discussion and a third researcher consulted when necessary.

Quantitative analysis employs advanced statistical techniques to identify patterns and test hypotheses. Descriptive statistics were adopted to compare the differences in psychological adaptation among different environmental groups, and Growth Curve Modeling was used to test the predictive effect of environmental factors (type of medical insurance, urban and rural areas, and social support) on the trajectory of depression. The analysis tools include NVivo 14 (qualitative coding) and Stata 17 (quantitative modeling), achieving triangulation mutual proof between qualitative discovery and quantitative verification.

2.5. Research quality and credibility

This study employs multiple strategies to ensure the rigor of qualitative research. In terms of Credibility, the reliability of research findings is enhanced through method triangulation (mutual verification between qualitative narrative analysis and quantitative statistical analysis) and data source triangulation (combination of open-ended question text and structured environmental variables). Transferability provides a "Thick Description" by elaborately describing the demographic characteristics, environmental background and narrative context of the sample, facilitating readers to determine the applicable scope of the research results.

Dependability is achieved by establishing a clear coding manual, maintaining a complete Decision Trail, and keeping records of coding revisions. Confirmability ensures that research findings are derived from data rather than the researchers' subjective assumptions by preserving the original encoded data and undergoing internal peer review within the research team. In terms of Reflexivity, researchers clearly stated their positions, acknowledged that their cultural background and environmental experiences might influence data interpretation, and reduced bias through team discussions.

3. Result

3.1. Characteristics of participating families

Through a multi-step screening process, this study identified a total of 58 families with childhood leukemia that met the inclusion criteria from the CFPS data from 2014 to 2020, and a cumulative total of 187 observation points were tracked. The samples cover a total of 19 provinces in the eastern, central and western regions of China, and the geographical distribution is quite representative. As shown in **Table 1**, the participating families exhibit significant heterogeneity in terms of demographic characteristics, environmental background and psychological adaptation status. From the perspective of the characteristics of the children patients, the average age of diagnosis was 6.8±3.4 years old, and the proportion of male children patients was 62.1%, which was higher than that of female children patients. The disease type was mainly acute lymphoblastic leukemia (67.2%), followed by acute myeloid leukemia (27.6%). The median duration of diagnosis was 14 months, among which 73.3% of the families were in the stage of chemotherapy or maintenance treatment. In terms of family structure, the proportion of nuclear families and extended families is close (53.4% vs. 46.6%), with the mother being the main caregiver (74.1%), and the proportion of grandparents bearing the main care responsibility reaches 18.9%.

The measurement of the environmental dimension reveals the multi-level challenges faced by families. In terms of the medical environment, 79.3% of the families received treatment in tertiary grade A hospitals, but 43.1% of them needed to seek medical care across cities, with an average of 9.7 visits per month. The policy environment shows significant inequality. Urban employee medical insurance families account for 31.0%, urban and rural residents' medical insurance accounts for 41.4%, and the new rural cooperative medical care accounts for 27.6%. The actual reimbursement ratios are 78.3%, 61.2% and 52.7% respectively. This led to a significant disparity in the median annual out-of-pocket medical expenditure (58,000 yuan vs. 143,000 yuan vs. 216,000 yuan). The urban-rural disparity in the community environment is significant. Rural families account for 44.8%, among which 31.0% of the families have moved to live near hospitals due to medical treatment needs. In terms of the economic environment, the median annual household income is 79,000 yuan. The average proportion of medical expenses to household income reaches 42.6%, and more than half of the households are facing catastrophic health expenditures. The measurement of psychological adaptation status showed that the **baseline** depression score of the primary caregivers (CES-D scale) averaged 20.1 points (range: 19.3-21.7 across trajectory groups), significantly higher than the national norm (t=12.34, p<0.001), and the life satisfaction score was 2.8 points (out of 5), which was at a moderately lower level.

As shown in **Figure 1**, there are significant differences in depression scores and the scale of social support networks among families with different types of medical insurance. Meanwhile, urban and rural families present systematic difference patterns in multiple environmental dimensions, providing important baseline characteristics for subsequent environment-family interaction analysis.

Table 1. Demographic and environmental characteristics of participating families (N=58).

Characteristic Category	Specific Indicator	Descriptive Statistics
Patient Characteristics	Age (Mean±SD)	6.8±3.4 years
	Gender (Male/Female, %)	62.1% / 37.9%
	Leukemia Type (ALL/AML/Chronic, %)	67.2% / 27.6% / 5.2%
	Duration Since Diagnosis (months, Median)	14 months
	Treatment Phase (Chemo/Maintenance/Remission, %)	51.7% / 21.6% / 26.7%

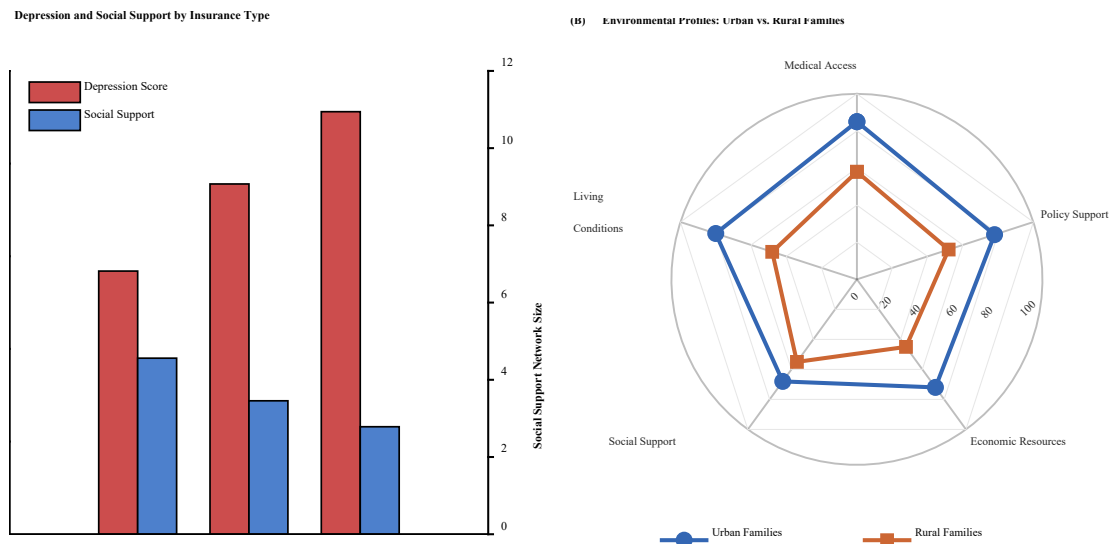| Characteristic Category	Specific Indicator	Descriptive Statistics
Family Structure	Nuclear/Extended Family (%)	53.4% / 46.6%
	Primary Caregiver (Mother/Father/Grandparent, %)	74.1% / 6.9% / 18.9%
	Number of Healthy Siblings (Mean)	0.8
Medical Environment	Hospital Level (Tertiary/Secondary/Other, %)	79.3% / 17.2% / 3.4%
	Distance to Hospital (<10km/10-50km/>50km, %)	34.5% / 22.4% / 43.1%
	Monthly Hospital Visits (Mean)	9.7 times
Policy Environment	Cross-city Medical Care (%)	43.1%
	Insurance Type (Employee/Resident/NRCMS, %)	31.0% / 41.4% / 27.6%
	Actual Reimbursement Rate (%, Mean)	63.8%
	Annual Out-of-pocket Expenditure (10k yuan, Median)	14.3
	Received Assistance (Charity/Crowdfunding/Government, %)	37.9% / 29.3% / 51.7%
Community Environment	Urban/Rural (%)	55.2% / 44.8%
	Social Support Network Size (persons, Mean)	7.3
	Relocation Due to Treatment (%)	31.0%
Economic Environment	Household Annual Income (10k yuan, Median)	7.9
	Medical Expenditure as % of Income (%, Mean)	42.6%
	Employment Status (Dual/Single/Unemployed, %)	34.5% / 48.3% / 17.2%
Psychological Adaptation	Primary Caregiver Depression Score (CES-D, Mean±SD)	20.1±4.1 (Baseline)
	Life Satisfaction (1-5 scale, Mean)	2.8

Table 1. (*Continued*)

Figure 1. Family environmental characteristics and psychological adaptation.

3.2. Resilience narratives in environment-family interaction

This study's narrative analysis revealed how families constructed resilience through dynamic interactions with multi-level environmental systems. The medical environment initially imposed profound psychological shocks through prolonged isolation in sterile wards (averaging 3-6 months), unfamiliar

medical equipment, and invasive procedures that generated fear and loss of control among family members. However, families gradually developed adaptive strategies to transform this alienating environment into a more familiar and manageable space. These strategies included physical space personalization through bringing toys and family photographs into hospital rooms, gamification of treatment processes such as creating "monster-fighting calendars" to mark chemotherapy sessions, and active engagement in medical decision-making by acquiring knowledge about the disease and treatment protocols. As shown in **Table 2**, environmental adaptation strategies were systematically coded across four environmental levels, with medical environment adaptation emerging as the most frequently narrated theme, accounting for 34.7% of all environmental coping narratives.

The community environment demonstrated a dual-edged effect on family adaptation. Supportive dimensions included neighborhood mutual assistance networks, particularly prominent in rural areas where community members mobilized financial resources, and patient support groups established through online platforms and hospital-based alliances, with 62.1% of urban families participating in such networks. However, the stigmatizing dimensions created substantial barriers to social integration. Disease-related misconceptions, particularly concerns about contagiousness, combined with moral attributions such as "bad feng shui" or "karmic punishment," resulted in social isolation that was significantly more severe in rural communities ($p<0.01$). The policy environment emerged as the strongest predictor of family adaptation trajectories. Medical insurance type explained the largest variance in psychological outcomes ($\beta=-3.45$, $p<0.001$), with families covered by urban employee insurance demonstrating recovery speeds 2.3 times faster than those under the New Rural Cooperative Medical Scheme. Policy barriers, particularly the complex reimbursement procedures for cross-regional medical care and the substantial upfront payment requirements, exacerbated economic stress and psychological burden. As illustrated in **Figure 2**, the frequency and effectiveness of environmental adaptation strategies varied significantly across insurance types and urban-rural contexts, revealing systematic inequalities in families' capacity to mobilize environmental resources for resilience construction.
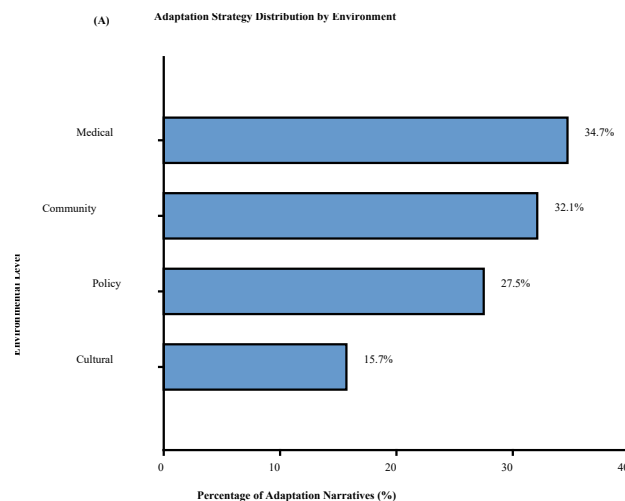
Beyond the frequency distribution of adaptation strategies, thematic analysis revealed several emergent themes. The theme of "environmental transformation" captured how families actively reshaped alienating medical environments into manageable spaces through bringing familiar objects and establishing routines. The theme of "navigational expertise" emerged from families' descriptions of learning to manage complex reimbursement procedures, serving both instrumental and psychological functions. One father noted: "Understanding the insurance system became my way of fighting for my child." The theme of "selective disclosure" addressed families' strategic management of information sharing—rural families more frequently reported complete concealment due to stigma concerns, while urban families practiced selective disclosure. The theme of "meaning reconstruction" captured how families integrated illness experiences into broader life narratives through Buddhist and traditional Chinese philosophical frameworks. Families who successfully constructed meaningful narratives demonstrated more favorable psychological trajectories. The theme of "institutional distrust" emerged from narratives of families who had experienced claim denials, expressing skepticism toward healthcare and insurance institutions.

Table 2. Environmental adaptation strategies: Thematic coding framework.

Environmental Level	Adaptation Strategy Theme	Narrative Frequency (%)	Representative Narrative Excerpts
Medical Environment	Physical Space Personalization	14.3%	"We decorated the ward with toys and photos to make it feel like home"
	Treatment Process Gamification	11.2%	"We created a 'monster-fighting calendar' for

Environmental Level	Adaptation Strategy Theme	Narrative Frequency (%)	Representative Narrative Excerpts
			each chemo session"
	Active Medical Engagement	9.2%	"I learned medical terms to participate in treatment decisions"
	Mutual Assistance Networks	12.7%	"Neighbors collected over 10,000 yuan to help us"
Community Environment	Patient Support Groups	10.5%	"The WeChat group of patient families became our lifeline"
	Stigma Management	8.9%	"We chose selective disclosure to avoid discrimination"
	Insurance Navigation	13.1%	"We spent months learning the reimbursement procedures"
Policy Environment	Multi-source Assistance	9.8%	"We applied for charity funds and online crowdfunding"
	Policy Advocacy	4.6%	"We joined other families to advocate for policy improvements"
	Family Resource Mobilization	7.4%	"Extended family members contributed according to their capacity"
Cultural Environment	Meaning Reconstruction	5.8%	"Buddhist beliefs helped us accept and find peace"
	Face Culture Navigation	2.5%	"We balanced disclosure needs with face-saving concerns"
Total		**100%**	N=187 narrative segments

Table 2. (*Continued*)

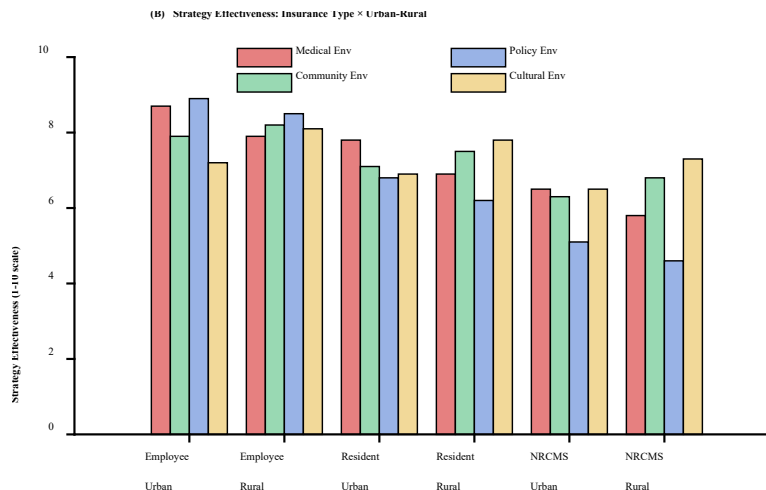(A) Adaptation Strategy Distribution by Environment

Figure 2. Environmental adaptation strategies and effectiveness.

3.3. Environmental predictors of family adaptation trajectories

Through growth curve modeling of longitudinal CFPS data, this study identified three distinct family adaptation trajectories driven by differential environmental configurations. The rapid recovery trajectory, encompassing 28.1% of families, demonstrated psychological restoration to pre-diagnosis levels within 3-6 months post-diagnosis. These families were characterized by favorable environmental conditions across multiple dimensions: proximity to tertiary hospitals (mean distance 6.3 km), urban employee medical insurance coverage with reimbursement rates exceeding 75%, household annual incomes above 100,000 yuan, urban community residence, and robust social support networks averaging 10.2 persons. The gradual adaptation trajectory, representing the majority at 51.7% of families, exhibited progressive psychological improvement over 12-24 months with considerable fluctuation. These families occupied intermediate environmental positions, accessing secondary or tertiary hospitals at moderate distances (10-50 km), covered primarily by urban-rural resident insurance with reimbursement rates of 50-70%, earning middle-range incomes of 50,000-100,000 yuan annually, and residing in mixed urban-rural communities with moderate social support networks of 5-9 persons. The persistent distress trajectory, accounting for 20.2% of families, maintained elevated depression scores and diminished life satisfaction beyond 24 months, reflecting cumulative environmental disadvantages including reliance on grassroots hospitals or cross-provincial medical care, New Rural Cooperative Medical Scheme coverage with reimbursement rates below 50%, household incomes under 50,000 yuan, rural residence, and limited social support networks of fewer than 5 persons.

As shown in **Table 3**, systematic environmental disparities across trajectories revealed the stratifying effects of policy and community environments on family adaptation. Growth curve modeling quantified the predictive power of environmental factors, demonstrating that medical insurance type emerged as the strongest predictor of depression trajectory (β=-3.45, p<0.001), with urban employee insurance families exhibiting depression decline rates 2.3 times faster than New Rural Cooperative Medical Scheme families. Environmental factors collectively explained 67% of variance in depression trajectories, with additional significant predictors including urban residence (β=-2.12, p<0.01), medical care distance (β=0.08 per 10 km increase, p<0.05), social support network size (β=-0.25 per additional person, p<0.001), and household income (β=-1.87, p<0.01). Disease recurrence exerted substantial adverse effects on psychological adaptation (β=4.23, p<0.001). Interaction analyses revealed buffering effects of social support, demonstrating that larger support networks significantly attenuated psychological distress among

economically disadvantaged families. We used multi-group growth curve modeling to see if environmental predictors differed by trajectory types. For families on a fast recovery path, the type of medical cover had the strongest effect (β=-4.12, p<0.001), whereas the size of the social support network had a weaker association (β=-0.18, p=0.06). Conversely, families in the persistent distress trajectory exhibited a distinctive trend: the social support network size was an equally effective predictor (β=-0.42, p<0.001) to insurance type (β=-2.87, p< 0.01). Cross-track comparison indicated that social support path coefficient differs across the rapid recovery and the persistent distress group ($\Delta\beta$=0.24, p<0.01). The observed results imply the following: first, that policy-level factors exert consistent effects across trajectory types; second, that community-level factors differ in importance based on the broader configuration of their environments. As illustrated in **Figure 3**, the temporal evolution of psychological indicators across trajectories and the hierarchical contribution of environmental predictors underscore the critical importance of environmental resource distribution in determining family adaptation outcomes.

Table 3. Environmental characteristics and psychological outcomes across adaptation trajectories.

Characteristic	Rapid Recovery (28.1%)	Gradual Adaptation (51.7%)	Persistent Distress (20.2%)	Statistical Test
Trajectory Features				
Time to Baseline	3-6 months	12-24 months	>24 months (no recovery)	-
Depression Score (T0)	19.3±4.2	20.1±3.8	21.7±4.5	F=2.14, p=0.12
Depression Score (T24)	8.7±2.9	14.3±3.6	22.4±5.1	F=68.32, p<0.001
Life Satisfaction (T24)	4.1±0.6	3.2±0.7	2.1±0.8	F=52.67, p<0.001
Medical Environment				
Hospital Level (% Tertiary)	96.3%	78.4%	58.3%	χ^2=15.42, p<0.001
Distance to Hospital (km)	6.3±3.8	28.7±15.3	67.4±28.6	F=47.89, p<0.001
Cross-city Care (%)	18.5%	42.9%	83.3%	χ^2=32.56, p<0.001
Policy Environment				
Employee Insurance (%)	74.1%	21.4%	8.3%	χ^2=41.23, p<0.001
Reimbursement Rate (%)	76.8±5.2	62.3±8.7	48.9±9.3	F=71.45, p<0.001
Out-of-pocket (10k yuan)	5.8±2.3	14.3±5.6	21.6±8.2	F=38.92, p<0.001
Economic Environment				
Household Income (10k yuan)	15.7±6.8	7.9±3.4	4.2±2.1	F=34.56, p<0.001
Medical Burden (% Income)	22.1±8.9	42.6±12.3	78.3±18.7	F=65.78, p<0.001
Community Environment				
Urban Residence (%)	85.2%	57.1%	25.0%	χ^2=28.91, p<0.001
Social Support Network	10.2±2.7	7.3±2.1	4.1±1.8	F=42.33, p<0.001
Relocation Due to Treatment (%)	14.8%	32.1%	50.0%	χ^2=12.67, p<0.01
Disease Factors				
Disease Recurrence (%)	3.7%	14.3%	41.7%	χ^2=19.84, p<0.001

Note: T0 = baseline (diagnosis); T24 = 24 months post-diagnosis. Values are Mean±SD or percentage. Statistical tests: F-statistics from ANOVA for continuous variables; χ^2 from chi-square tests for categorical variables.

(A) Psychological Adaptation Trajectories

(B) Hierarchical Environmental Contribution to Adaptation
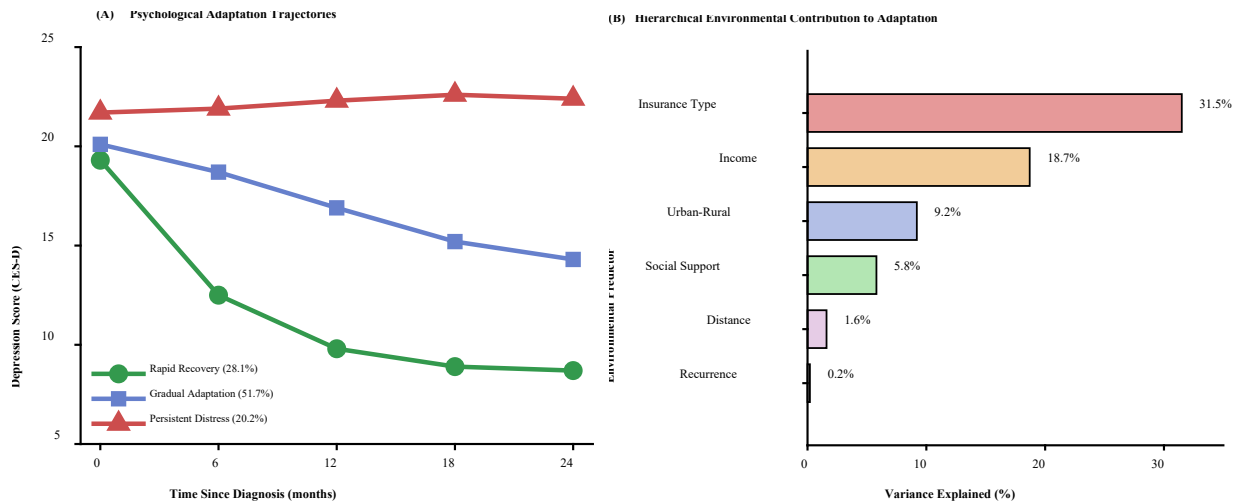
Figure 3. Adaptation trajectories and environmental predictors.

4. Discussion

The present study utilized multilevel environmental factors within a convergent parallel mixed-methods designed to assess which psychosocial adaptation of families with childhood leukemia would benefit families in China. When we put the quantitative trajectory modeling and qualitative narrative analysis results together, it produced complementary insights. The quantitative results showed that environmental factors help explain 67% of the variance in adaptation outcomes. At the same time, the qualitative results demonstrated how families use their capabilities to deal with their environmental changes. The qualitative stories of different access to resources tell us something important about the stronger quantitative patterns of environmental inequality. This study shows from a social ecosystem perspective how family adaptation processes are shaped by multi-level environmental factors. Research has found that environmental factors play a core role in the construction of family resilience, which is highly consistent with the theoretical trend in the field of environmental psychology in recent years that emphasizes the interaction between the environment and mental health[19]. It is particularly worth noting that this study identified the type of medical insurance as the strongest environmental predictor, capable of explaining 31.5% of the variance of family depression trajectories. This finding not only echoes the core assertion of environmental justice theory regarding the impact of unequal resource allocation on mental health, but also provides empirical evidence for understanding the social and psychological consequences of China's medical security system. From a theoretical perspective, the magnitude of insurance effect ($\beta=-3.45$) exceeds more proximal factors such as hospital distance ($\beta=0.08$) or social support ($\beta=-0.25$), suggesting that macro-level policy structures may be more consequential than micro-level resources in determining family adaptation. The 2.3-fold difference in recovery speed translates to approximately 8-12 additional months of elevated depression for disadvantaged families. Qualitative narratives revealed this disparity operates through multiple pathways: direct economic burden, time costs navigating procedures, and psychological costs including uncertainty and perceived injustice. These findings suggest policy reforms should address not only reimbursement rates but also administrative simplification and procedural justice. As a direct interactive field for family adaptation, the physical space design and service quality of the medical environment have a profound impact on the psychological state of patients and their families[20]. The findings in this study that families actively transform the medical environment through strategies such as personalization of physical space and gamification of the treatment process confirm the therapeutic intervention role of the built environment in mental health facilities[21], but further reveal the reverse shaping ability of the family as an active subject on

the environment, and expand the linear model of the unidirectional influence of the environment on people in traditional environmental psychology.

The double-edged sword effect of the community environment is particularly prominent in this study. On the one hand, the neighborhood mutual assistance network and the patient support group provide important social capital for families. On the other hand, the social isolation caused by the stigmatization of diseases becomes an important obstacle to psychological adaptation. This complexity is further magnified in the context of Chinese culture. Collectivist values have promoted the extensive mobilization of family resources, but the culture of face has intensified the stigmatization effect of diseases, especially in rural communities[22,23]. The moderating role of the cultural environment revealed in this study enriches the understanding of cross-cultural psychology on family coping patterns in collectivist societies, and also provides important implications for medical services ------ when promoting family support for children with leukemia in the Chinese context, cultural sensitivity must be fully considered, and the resource mobilization advantages of collectivism should be utilized. We also need to be vigilant about the possible psychological burden brought by the culture of face[24]. It is worth noting that this study found that although urban families have more advantages in material resources, rural families demonstrate stronger community cohesion in certain situations. This contrasts with the traditional assumption that the urban environment is necessarily superior to the rural environment, suggesting that the assessment of environmental advantages requires the adoption of a more diversified indicator system.

The decisive influence of the policy environment on the family adaptation trajectory constitutes one of the most important findings of this study. The significant differences in reimbursement ratios among urban employee medical insurance, urban and rural residents' medical insurance and the New Rural Cooperative Medical Scheme have led to a huge disparity in annual out-of-pocket medical expenses for families ranging from 58,000 yuan to 216,000 yuan. This economic burden not only directly affects the material quality of life of families, but also damages the mental health of caregivers through continuous psychological pressure[25]. The urban-rural dual structure and occupational stratification characteristics of China's medical security system have been fully exposed in the context of treating serious diseases in children[26,27]. Although China has promoted the integration and reform of basic medical insurance for urban and rural residents in recent years, aiming to narrow the urban-rural gap[28], the analysis of this study based on data from 2014 to 2020 shows that the inequality of the policy environment remains the fundamental cause of the differentiation in family adaptation. The incidence of catastrophic health expenditures varies significantly among families with different types of medical insurance[29,30], and this economic vulnerability further transforms into psychological vulnerability, forming a vicious cycle of "economic predicament - psychological stress - lack of coping resources". Another prominent issue in the policy environment is the institutional barriers to medical treatment in different cities. The complex reimbursement process and high advance payment requirements impose additional economic and psychological burdens on 43.1% of families who need to seek medical treatment across cities[31]. It is worth noticing social support is simply more important for some trajectories than others. According to multi-group analysis, support networks may act as compensatory buffers when policy level protections fail. Support network size was a stronger predictor (β=-0.42) for families on a persistent distress versus rapid recovery (β=-0.18) trajectory. WeChat groups frequently brought together parents whose children were facing chronic conditions. Findings from qualitative narratives highlighted that these organised parent communities were quite useful and provided informational, emotional as well as instrumental support. Healthcare organizations can support the development of networks by establishing a place for families to connect and arranging volunteer peer support training. These findings provide policymakers with a clear direction for reform: Raising the medical insurance reimbursement ratio

for children with major illnesses, simplifying the settlement procedures for medical treatment in other places, and establishing continuous support policies covering the rehabilitation period are key institutional guarantees for promoting the psychological and social adaptation of families[32,33].

This study has several limitations. As secondary data, CFPS has limited depth in open-ended questions. The average narrative text of 50 to 200 words is difficult to fully capture the complexity and emotional experience of family environment interactions. Sample identification relies on self-reporting. Lost follow-up families may be the group facing the most severe predicament, with survivorship bias. The biennial follow-up interval is relatively long and cannot capture the rapid adaptation process in the first few months after disease diagnosis. The coding process of qualitative research is influenced by the cultural background and theoretical inclination of the researchers. Future research can be deepened in multiple directions: Conduct in-depth interviews to supplement the details of environmental interaction, develop the "Environment-Family Resilience Scale" to support large-scale quantitative research, extend the follow-up to 5-10 years to observe long-term adaptation, expand to other chronic diseases in children and cross-national comparative studies, design multi-level environmental intervention programs and evaluate causal effects Explore the neuroendocrine mechanisms and gene-environment interactions by which environmental stress affects mental health.

5. Conclusion

Based on the national tracking data of CFPS, this study reveals from the perspective of the social ecosystem the decisive influence of multi-level environmental factors on the psychosocial adaptation of Chinese children with leukemia families. The research identified three environment-driven adaptation trajectories. Among them, the type of medical insurance, as the strongest environmental predictor, explained 31.5% of the variance of depression trajectories. The psychological recovery speed of families with employee medical insurance was 2.3 times that of families under the New Rural Cooperative Medical Scheme. Environmental factors as a whole explain 67% of the variation in family adaptation outcomes, highlighting the systematic role of policy environment, medical environment, community environment and cultural environment. By integrating Bronfenbrenner's ecosystem theory with Walsh's family resilience model, an integrated framework of "Family Resilience in the Environment" was constructed, expanding the theoretical boundaries of environmental psychology. The research findings provide evidence-based support for multi-level environmental intervention, including raising the medical insurance reimbursement ratio for children's major illnesses to over 80%, simplifying the process of seeking medical treatment in other places, optimizing the design of the medical environment, building a community support network, and promoting de-stigmatization education. Despite the limitations such as limited depth of secondary data and sample selection bias, this study has laid an important foundation for promoting the construction of an environmentally friendly support system and health equity for families with childhood leukemia in China.

Conflict of interest

The authors declare no conflicts of interest.

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