Research Paper

Rethinking Urban Play Equity in Cold Climates: Research on the Efficiency-Equity Dilemma and Optimization Path of Children's Play Spaces in Cold-Region Cities During Winter

Yue Ma; Xinyang Wang; Hong Leng
Harbin Institute of Technology, China

Abstract

In cold-region cities, extreme winter conditions significantly limit children's access to public play spaces, challenging the goal of child-friendly urban development. This study investigates the efficiency-equity dilemma of these spaces during winter, using Harbin, China, as a case study. Through field observations and surveys in neighborhoods of varying socioeconomic levels, we evaluated play spaces across three dimensions: spatial supply (facility usability, safety), temporal adaptability (alignment with children's free time), and experiential efficiency (play diversity, social interaction, satisfaction).

Findings reveal that children in higher-income communities benefit from better-maintained, safer, and more usable play spaces, supporting diverse and sustained activities. In contrast, those in lower-income areas face poorly maintained facilities, unsafe surfaces, and inadequate snow clearance, leading to shorter, less varied play and lower satisfaction. A notable temporal-spatial mismatch was also observed: children with more free time often lack adequate spaces, while those with better facilities have less time due to academic pressures.

The study concludes that winter climate amplifies existing social inequalities. It calls for differentiated planning strategies that address not only spatial distribution but also seasonal maintenance and temporal coordination to ensure equitable and efficient play opportunities for all children in cold cities.

Keywords

Cold-region cities; Children's play spaces; Winter usability; Efficiency-equity dilemma

1. Introduction

With the deepening of the concept of "child-friendly cities" around the world, the quality of life of children and their experiences in public spaces have become dimensions gradually important in the evaluation of the urban livability and social equity. The United Nations Convention on the Rights of the Child explicitly provides that children have the fundamental right to play and engage in recreational activities. Whether a city can offer safe, accessible, continuous and equitable play environments has become an important indicator to assess the capacity of urban public service provision and governance (Jansens R, et al., 2023). Children's play space is not only a place where children engage in physical activity, but also an important place for children to interact socially, express their emotions, and learn, and it plays an irreplaceable role in children's growth process (Bai Jie, et al., 2025).

However, in cities that are situated in cold areas, extreme winter climates have a significant impact on the accessibility of public spaces. In Northeast China, issues including consistently low temperatures ranging for several months each winter, snow accumulation and icy surfaces, strong winds, and reductions in the hours of daylight have a significant negative impact on the comfort, safety, and usability of outdoor spaces (Shao L, et al., 2022). At the same time, problems such as ice damage to the facilities, untimely snow removal, slippery ground surfaces and lack of shelter and heating facilities are pervasive, making it difficult for the children to participate in routine outdoor activities during winter (Xiaoyun He, et al., 2023). Under these circumstances, the opportunities for children to play every day is compressed, their behaviors are limited, and their physical and mental development may even be affected.

Meanwhile, with the rapid urbanization and changes in population structure, the inequality among different socio-economic groups in the quality of community space, public services covering and resource allocating has become increasingly apparent (ZHU Peijuan, et al., 2023). These disparities are further compounded during the winter, resulting in differentiated consequences in children's play opportunities, quality of behavior, and social interactions (Maria Rubio-Cabañez, 2025). Although the recent planning of children's play spaces has started to take into consideration spatial equity, as well as population-density matching principles, systematic research is lacking with respect to whether or not children are able to effectively utilise these spaces, particularly under extreme winter climate conditions. Existing literature tends to focus on spatial balance from the supply perspective while overlooking "efficiency differences" and "temporal-spatial mismatches" on the usage side. Therefore, this study raises a number of important questions: under extreme winter climate conditions, do children from different socio-economic groups have access to play experiences of equal quality? How do physical conditions of spaces, time available, and behavioral experiences interact to determine the efficiency of children's use of play spaces? Does the cold climate increase disparities in efficiency of use?

Based on the above-mentioned issues, this study takes Harbin as a case study to explore the usage disparities of children's public play spaces in winter in cold-region cities and their underlying mechanisms from an efficiency-equity perspective. The research compares four communities based on different land values and construction time periods, using behavioral observation, questionnaire surveys and spatial measurement to build a comprehensive efficiency assessment framework that includes three dimensions:

(1)Spatial Supply Efficiency: Emphasizes on quality of space, facility conditions, winter usability, safety and maintenance levels (Reimers, A.K. & Knapp, G., 2017).

(2)Temporal Adaptability Efficiency: Looks to see if there is a mismatch between the amount of time children have and the opening times of play facilities (Ren, X., et al., 2025).

(3)Experiential Efficiency: Judges the diversity of children's play behavior, intensity of activities, social opportunities and subjective satisfaction (James, M. E., et al., 2022).

These three dimensions portray collectively the experience of children in winter play spaces and the physical capacity of support of the spaces, but also the limits within the social time structures that constrain outdoor activities, while different communities show differences in the quality of children's experiences. By analyzing comprehensive efficiency, this study aims to reveal the interaction between cold-region climate and socio-economic disparities in affecting the realization of children's right to play, and to propose different optimization strategies from the perspective of planning practice to promote the development of child-friendly spaces and improve climate resilience in cold-region cities.

2. Research Framework

Based on the interaction among winter climate, community spatial conditions, and children's outdoor behavior, this study constructs an analytical framework composed of three dimensions: spatial supply efficiency, temporal adaptability efficiency, and experiential efficiency. These dimensions are used to explain how physical space, daily time structure, and play experience jointly shape the efficiency-equity dilemma of children's winter play spaces in cold-region cities.

3. Research Design

This study combines the multi-source data of space observation, questionnaire survey, and behavioral records to build a comprehensive analytical system to assess the winter usage efficiency of community children's play spaces. The research design has three components: the choice of the study areas, research methods, and the system of indicators.

3.1. Study Area Selection

To cover the differences in construction conditions, community forms and socio-economic features, this study selects four representative communities in Harbin with different construction periods and obvious differences in land value as the research subjects. These four communities respectively represent older communities, mid-level communities and relatively newer communities with higher land values and have notable differences in terms of spatial conditions, facilities status and management levels.

Table1. The Four Representative Communities

Community	Average House Price	Construction Era
Community1	7000RMB/㎡	1980s
Community2	8200RMB/㎡	2003s
Community3	9800RMB/㎡	2022s
Community4	14000RMB/㎡	2020s

3.2. Methods

This study uses combination of qualitative and quantitative methods to develop the overall research framework using the following three types of data collection and analysis techniques:

3.2. 1. Behavior Mapping

Children's outdoor play behaviors in the four communities were recorded during typical winter periods and consisted of the following information: behavior types; frequency and duration of activities; peer interactions; and spatial preferences and activity distribution among children of different ages.

3.2. 2. Questionnaire Survey

Questionnaires were given to children's guardians and community residents to gather information on: evaluations of play space facilities, safety, lighting and maintenance; children's daily available time and willingness to go outside in winter; subjective assessments of play experiences, social opportunities and satisfaction; and willingness to come back in winter, and constraints on behavior. The results of the questionnaire were used as the basis for the assessment of Experiential Efficiency and Temporal Adaptability Efficiency.

3.2. 3. Field Observation & Spatial Measurement

Objective physical information of play spaces was gathered through on-site play space inspections, including: Site area, number and types of facilities; color and visual environmental quality; winter usability; lighting conditions, sun exposure, and microclimate (e.g., shelter structures). These data formed the basis for the evaluation of Spatial Supply Efficiency.

These three methods complement each other and together build a multi-dimensional system of data for children's winter play spaces.

3.3. Indicator System

Based on the research framework, the research in this thesis builds a comprehensive evaluation indicator system that is rooted in the three core dimensions of efficiency and the basic spatial information.

3.3.1. Basic Spatial Information

First, the study collected fundamental information on community play spaces, including the items listed in Table 2.

Table2. Basic Spatial Information Indicators

Indicator	Definition
Playground area (m^2)	Total usable area of the play space, excluding parking or green buffer zones.
Number of play facilities	Count of fixed and functional play equipment available (e.g., slides, swings, climbing frames).
Facility diversity	Number of distinct facility types present (climbing, balance, sliding, sand, creative play, etc.).
Seating and resting facilities	Number of benches, shelters, or rest areas for caregivers and children.

Color richness / visual appeal	Degree of color variety and visual stimulation in the playground environment (1–5 rating).
Ground material type	Main surface materials (e.g., rubber mat, snow-compacted soil, asphalt) and their seasonal safety characteristics.
Shelter and enclosure	Presence of windbreaks, semi-enclosed structures, or canopies providing microclimate comfort.

3.3.2. Spatial Supply Efficiency

This study uses the variables under Spatial Supply Efficiency to measure the basic support capacity of play spaces during winter, as shown in Table 3.

Table3. Spatial Supply Efficiency Indicators

Indicator	Definition
Facility condition	Condition and maintenance level of playground equipment during winter. (1–5 rating)
Winter usability	Degree to which facilities remain functional and accessible under snow and low temperature.(1–5 rating)
Safety of surface	Presence of anti-slip materials, snow/ice clearance, and perceived safety from slipping risks.(1–5 rating)
Lighting adequacy	Adequacy of lighting for evening or dark-hour use in winter.(1–5 rating)
Maintenance & management	Frequency and quality of snow removal, cleaning, and facility repair.(1–5 rating)

3.3.3. Temporal Adaptability Efficiency

The study uses the variables under the Temporal Adaptability Efficiency dimension to measure the alignment between the opening conditions of play spaces and children's daily available time, as shown in Table 4.

Table4. Temporal Adaptability Efficiency Indicators

Indicator	Definition
Time alignment with children's schedule	Consistency between children's discretionary time (after school/weekend) and playground availability. (1–5 rating)
Parental flexibility perception	Parents' perception of whether management adapts hours under extreme weather or peak times.(1–5 rating)
Children's free play time	Average daily time available for outdoor play during winter (minutes)(1–5 rating,1:0-20min,2:20-40min,3:40-60min,4:60-80min,5:80min-).
Visiting frequency	Number of playground visits per week during winter.(1–5 rating)

3.3.4. Experiential Efficiency

The study uses the variables under the Experiential Efficiency dimension to assess children's actual space use experiences from both behavioral and subjective perspectives, as shown in Table 5.

Table5. Experiential Efficiency Indicators

Indicator	Definition
Play behavior diversity	Number and variety of play types observed (climbing, sliding, running, social play, etc.).
Social interaction frequency	Number of peer interactions per child per hour during playtime.
Play duration per visit	Average time a child spends at the playground per visit (minutes).(1–5 rating,1:0-20min,2:20-40min,3:40-60min,4:60-80min,5:80min-)
Perceived play satisfaction	Parents' or children's overall satisfaction with winter play experience (1–5 rating).
Perceived social opportunities	Perceived opportunity for children to make friends and interact with peers.(1–5 rating)
Willingness to revisit in winter	Likelihood that children/families continue visiting during cold season.(1–5 rating)

4. Results

Based on field observations, behavioral records, and questionnaire surveys in the four communities, this section compares children's winter play spaces from three dimensions: spatial supply efficiency, temporal adaptability efficiency, and experiential efficiency. The results show a clear differentiation among communities. Higher-resource and newer communities generally perform better in facility condition, winter usability, surface safety, and experiential quality, while older and lower-resource communities show weaker spatial support and lower play quality. However, the results also reveal that spatial quality alone does not determine play efficiency. A temporal-spatial mismatch is evident: children in lower-resource communities tend to have relatively more discretionary time but lack usable winter play spaces, whereas children in higher-resource communities have better spaces but less available time due to academic and family schedules. Therefore, the efficiency-equity dilemma of children's winter play spaces is produced by the interaction among spatial conditions, temporal constraints, and winter climate stress.

Table6. Survey Results

Community1 (Average house price≈7000RMB/㎡ Construction era≈1980s)		
Number of children who filled out the questionnaire: 15		
Number of parents who filled out the questionnaire: 5		
Basic Spatial Information	Playground area	180 ㎡
	Number of play facilities	2 swings
	Seating and resting facilities	1 pavilion with 4 benches
	Color richness / visual appeal	1 rate
	Ground material type	diamond floor
	Shelter and enclosure	none
Spatial Supply Efficiency Score	10	
Temporal Adaptability Efficiency Score	14	
Experiential Efficiency Score	12	
Community2 (Average house price≈8200RMB/㎡ Construction era≈2003s)		
Number of children who filled out the questionnaire: 12		

Number of parents who filled out the questionnaire: 6		
Basic Spatial Information	Playground area	500 ㎡
	Number of play facilities	1 big slide,1seesaw
	Seating and resting facilities	4 sets of tables and chairs
	Color richness / visual appeal	3 rate
	Ground material type	cement floor
	Shelter and enclosure	woods around the site
Spatial Supply Efficiency Score	12	
Temporal Adaptability Efficiency Score	15	
Experiential Efficiency Score	18	
Community3 (Average house price≈9700RMB/㎡ Construction era≈2022s)		
Number of children who filled out the questionnaire: 15		
Number of parents who filled out the questionnaire: 5		
Basic Spatial Information	Playground area	350 ㎡
	Number of play facilities	1 large slide, 3 swings, 4 wooden horses, 1 sandpit, 1 wooden bridge
	Seating and resting facilities	1 bench
	Color richness / visual appeal	4 rate
	Ground material type	Rubber floor and land
	Shelter and enclosure	woods around the site
Spatial Supply Efficiency Score	21	
Temporal Adaptability Efficiency Score	11	
Experiential Efficiency Score	26	
Community4 (Average house price≈14000RMB/㎡ Construction era≈2020s)		
Number of children who filled out the questionnaire: 6		
Number of parents who filled out the questionnaire: 2		
Basic Spatial Information	Playground area	200 ㎡
	Number of play facilities	2 large slide, 1seesaw, 4 wooden horses
	Seating and resting facilities	None
	Color richness / visual appeal	5 rate
	Ground material type	Rubber floor
	Shelter and enclosure	woods around the site
Spatial Supply Efficiency Score	21	
Temporal Adaptability Efficiency Score	11	
Experiential Efficiency Score	22	

From the point of view of basic spatial conditions, the four communities show a clear gradient in the aspects of site area, number of facilities, ground paving, color scheme, and natural elements. Communities with higher land values and more recent periods of construction have larger, better-equipped and better-maintained play spaces, doing better on visual quality, safety and microclimate conditions. High land value communities have brought in natural elements such as wooden bridges and trees which were often mentioned during observations and especially drew the attention of older children. In contrast, the play spaces in areas with low land value are smaller and have fewer facilities, dull colours and ice/slippery surfaces during winter, which makes it noticeably lower in spatial attractiveness. These differences are the basic background for differences in Spatial Supply Efficiency among the communities.

As for Spatial Supply Efficiency, facilities in high land value communities exhibit much higher integrity, winter usability, safety and lighting conditions than in low land value communities. Snow removal and regular maintenance is more complete to make spaces usable to some extent during the winter. Conversely, facilities in low land value communities are subject to increased frost damage, slow snow clearance and slippery surfaces, which means that many facilities are effectively "nominally present but practically unusable," with severe limits on children's range of activity and types of behaviour. Differences in spatial quality are also directly reflected in the structure of children's play behaviors: in communities with better environmental supports, children engage in longer and more diverse activities, but in communities with poor environmental supports, children's activities are compressed into short and repetitive actions, and are more vulnerable to safety risks (Engelberg, J.K., et al., 2016).

Temporal Adaptability Efficiency has patterns in which it differs from spatial supply quality. The study found that in low land value communities, family structures and daily rhythms are more relaxed and children have more discretionary time and some retention of willingness for outdoor activities in winter. However, because of poor spatial conditions these available times cannot be effectively used. In contrast, children in high land value communities have more crammed after school schedules, and extracurricular training and parental management further limit their available time, leaving less time for outdoor play despite having higher quality play spaces. As a result, children's winter play opportunities display a common "temporal-spatial mismatch" where children with time lack sufficient space, and children with high quality space lack sufficient time, resulting in efficiency constraints in both types of communities through different mechanisms, which is also true in studies related to adults (Hallum SH, et al., 2024).

In terms of Experiential Efficiency, differences between communities are even more dramatic. Communities with better spatial conditions not only support longer single session play behaviors, but higher-quality social interactions and more diverse combinations of play activities. Children within these spaces are more likely to form more stable groups of interactions, have slower rhythms of activity, are more immersed and satisfied. By comparison, in communities with poorer spatial conditions, the number of times that children are active may be higher, but each visit is shorter, activity patterns are monotonous, social interactions are limited, and experiential satisfaction is comparatively lower. Notably, children in low-resource communities demonstrate high levels of willingness to play, however, due to lack of space and management conditions, this willingness cannot be translated into effective experiences and this creates a significant gap.

5. Discussion

Finally, the results suggest that extreme winter climates have a clear amplifying effect. In spaces with favorable natural conditions and reasonable design and maintenance, a certain level of activity can be carried on even in winter. However, in communities with rudimentary facilities and poor maintenance, winter makes spaces almost totally unusable (Li Caili, et al., 2024). The effects of climate are even greater on play spaces in vulnerable communities, further increasing spatial disparities in winter (Luyao, H., et al., 2025). This not only limits children's opportunities for outdoor activities, but it also contributes to the differences between social groups in terms of physical development, social interactions and psychological experiences.

5.1. Differences in Spatial Quality as the Core Source of Efficiency and Equity Disparities

The research concludes that differences among communities in terms of site area, number of facilities, quality of maintenance and microclimate conditions are the basic sources of differences in children's play opportunities and experiences during winter. High land-value communities are able to maintain good upkeep and snow removal so that play spaces can be kept highly usable in winter. In contrast, low land-value communities experience problems such as damaged facilities, uncleared snow and slippery surfaces, which greatly limit the range of activities for children and, in some cases, make certain spaces completely unusable during winter.

These differences suggest that the cold climate is not the only reason children's play opportunities are reduced, rather the level of community resources and spatial management capacity determine accessibility. In other words, Spatial Supply Efficiency disparities in winter are indicative of structural inequalities, which are especially severe in cities in cold regions. Therefore, in the promotion of child-friendly development of cities in the cold regions, it is not enough to focus only on the spatial balance at the design level. Long-term maintenance, seasonal snow clearance and facility durability need also to be incorporated into frameworks for equity assessment (Larsson, A. & Chapman, D., 2020) (QU Hanjia, et al., 2025).

5.2. The Mismatch between Temporal and Spatial Resources Further Exacerbates Efficiency Issues

The research shows a mismatch in time and space between high land-value and low land-value communities. Children in low-resource communities have more free time, but because of poor spatial quality, this time cannot be turned into play experiences. Conversely, children in high-resource communities are placed under more academic pressure and have more scheduling demands on their families, so they have less time to take full advantage of high-quality spaces. This phenomenon suggests that children's play opportunities are not the outcome of the spatial supply but the result of the combined effects of the temporal structures and the spatial conditions. When time and space do not match, either too much spatial resources or time not used efficiently may decrease the efficiency of use, which may result in latent inequities in winter play opportunities. This suggests that in addition to planning in space, children's daily time regimes is an important institutional factor that influences the equity of play.

5.3. Winter Climate Conditions Have a Stronger Amplifying Effect on Vulnerable Communities

Extreme climatic conditions have a clear amplifying effect in the four communities. Communities with positive spatial conditions still have the opportunity to keep children active by snow removal, improved lighting, and facility maintenance while communities with weaker spatial conditions are more likely to have near total shutdown during the winter. This shows that winter climate and socio-economic disparities are strongly coupled: vulnerable communities not only experience direct pressures from cold climates but also have lower adaptive capacity due to resource limitations, leading to further delay in the range of activity diversity, duration of stay, and social opportunities compared with resource-rich communities. Winter climate as an external environmental stressor therefore contributes to seasonal inequities in children's play spaces in cold region cities, thereby underscoring the importance of marked seasonal adaptability in equity governance.

5.4. The Winter Play Environment Plays a Key Role in Shaping Children's Behaviors and Social Patterns

The findings show that the quality of the winter play environment not only influences children's willingness to engage in outdoor activities, but also influences the types of play that children can engage in as well as whether or not high-quality social interactions are possible. In communities where spaces are well-designed and maintained, children have the opportunity to participate in continuous, in-depth and socially interactive activities, while in communities with inadequate spatial resources, behaviors are likely to be "frequent but brief" and social relationships are more fragmented. This shows that the winter play environment is not just a physical environment, but also a behavioral regulation mechanism, which influences children's interaction patterns, emotional experiences, and even children's physical development and psychological resilience. Therefore, in cold climates, play environments should be considered as a fundamental public service for the development of children's capacity, rather than being considered a recreational facility provision.

6. Conclusion and Optimization Pathways

This study systematically analyzed winter play spaces for children in the 4 typified communities in Harbin from three dimensions of Spatial Supply Efficiency, Temporal Adaptability Efficiency, and Experiential Efficiency. The results show that community resource inequities and extreme climatic conditions together influence the structural inequities of children's play opportunities in winter: the difference of spatial conditions determines the usability and safety of winter, the difference of temporal structures has a different impact on the potential of children's real visits, and the behavioral and experiential quality is directly related to the actual performance of spaces in winter.

The results suggest that winter climate is not the sole factor that limits children's activities; its effect is greatly moderated by community maintenance capacity, facility quality and microclimatic conditions. High-resource communities have relatively high usability due to better maintenance and snow clearance, while low-resource communities have rapidly decreasing spatial quality during the winter months, resulting in a sharp decrease in the opportunity for children to play. At the same time, the temporal-spatial mismatch between the communities also further decreases the utilization efficiency of the space,

which causes children who lack available time but have available space, and children who have good space but lack time.

These findings suggest that child-friendly space development in cold-region cities should go beyond traditional design-focused considerations, to focus on maintenance systems, seasonal management, and the development of adaptive capacity in vulnerable communities. Winter play environments play a decisive role in children's behaviors and social interactions; therefore, public spaces in cold climates should be considered a critical public service that ensures children's developmental opportunities.

Overall, this study emphasizes the efficiency-equity dilemma of winter play spaces in cities with a cold climate and highlights the importance of making coordinated improvements in spatial quality, temporal allocation, and seasonal governance. The research presents empirical evidence of ways to improve the climate resilience and equity of children's spaces in cold region cities and offers guidance for future planning and policy formulation.

The limitations of this study should also be acknowledged. Since the empirical analysis was based on four typical communities in Harbin, future research should expand the sample to more cold-region cities to test the applicability and robustness of the proposed efficiency-equity framework. A year-round perspective is also needed to compare how children's behavior and spatial adaptability change across seasons. In addition, more precise behavioral data, such as GPS tracking, wearable devices, video observation, and child-centered interviews, could further improve the understanding of children's winter play experiences.

Reference

Jansens, R., Prellwitz, M., Olofsson, A. and Lynch, H. (2023) 'The Representation of Children's Participation in Guidelines for Planning and Designing Public Playspaces: A Scoping Review with "Best Fit" Framework Synthesis', International Journal of Environmental Research and Public Health, 20(10), p. 5823. Available at: https://doi.org/10.3390/ijerph20105823

Bai, J., Zhang, W., Xu, M., Xu, T. and Wang, M. (2025) 'Evidence-Based Design of Children-Friendly Activity Space Oriented Towards Nature Experience', Journal of Chinese Urban Forestry, 23(1), pp. 111-118. Available at: https://doi.org/10.12169/zgcsly.2024.05.01.0001

Shao, L., He, X., Tang, Y. and Wu, S. (2022) 'Outdoor Cold Stress and Cold Risk for Children during Winter: A Study in China's Severe Cold Regions', Buildings, 12(7), p. 936. Available at: https://doi.org/10.3390/buildings12070936

He, X., Shao, L., Tang, Y. and Wu, S. (2023) 'Improving children's outdoor thermal comfort: A field study in China's severely cold regions', Urban Climate, 51, p. 101620. Available at: https://doi.org/10.1016/j.uclim.2023.101620

Zhu, P., Huang, Q., Wan, Y. and Zou, Z. (2023) 'Spatial Differentiation and Influencing Factors of the Allocation Level of Urban Children's Public Service Facilities in China', Economic Geography, 43(11), pp. 55-67. Available at: https://doi.org/10.15957/j.cnki.jjdl.2023.11.007

Rubio-Cabañez, M. (2025) 'Stratifying cities: the effect of outdoor recreation areas on children's well-being', European Sociological Review, 41(3), pp. 472-486. Available at: https://doi.org/10.1093/esr/jcae028

Reimers, A.K. and Knapp, G. (2017) 'Playground usage and physical activity levels of children based on playground spatial features', Journal of Public Health, 25, pp. 661–669. Available at: https://doi.org/10.1007/s10389-017-0828-x

Ren, X., Guan, C., Chen, S., You, M., Li, Y. and Huang, K. (2025) Planning for Rhythmized Urban Parks: Temporal Park Classification and Modes of Action. arXiv. Available at: https://arxiv.org/abs/2509.02635

James, M.E., Jianopoulos, E., Ross, T., Buliung, R. and Arbour-Nicitopoulos, K.P. (2022) 'Children's Usage of Inclusive Playgrounds: A Naturalistic Observation Study of Play', International Journal of Environmental Research and Public Health, 19(20), p. 13648. Available at: https://doi.org/10.3390/ijerph192013648

Browning, C.R., Calder, C.A., Boettner, B., Tarrence, J., Khan, K., Soller, B. and Ford, J. (2021) 'Neighborhoods, Activity Spaces, and the Span of Adolescent Exposures', American Sociological Review, 86(2), pp. 201-233. Available at: https://doi.org/10.1177/0003122421994219

Engelberg, J.K., Conway, T.L., Geremia, C., Cain, K.L., Sallis, J.F., Glanz, K. and Saelens, B.E. (2016) 'Socioeconomic and race/ethnic disparities in observed park quality', BMC Public Health, 16, p. 395. Available at: https://doi.org/10.1186/s12889-016-3055-4

Hallum, S.H., Wende, M.E., Shariati, F.H., Thomas, K.M., Chupak, A.L., Witherspoon, E. and Kaczynski, A.T. (2024) 'Unearthing Inequities in the Relationship between Multiple Sociodemographic Factors and Diverse Elements of Park Availability and Quality in a Major Southern Metropolitan Region', International Journal of Environmental Research and Public Health, 21(2), p. 204. Available at: https://doi.org/10.3390/ijerph21020204

Li, C., Maruthaveeran, S., Shahidan, M.F. and Li, C. (2024) 'Cold city outdoor space utilisation patterns and constraints: A systematic review of empirical evidence', Urban Forestry & Urban Greening, 99, p. 128439. Available at: https://doi.org/10.1016/j.ufug.2024.128439

Luyao, H., Ling, L., Xinkai, L., Qiong, L. and Yechen, X. (2025) 'Outdoor thermal comfort benchmarks and optimization design for children in open parks of hot summer and cold winter region', Scientific Reports, 15, p. 16702. Available at: https://doi.org/10.1038/s41598-025-95979-8

Larsson, A. and Chapman, D. (2020) 'Perceived impact of meteorological conditions on the use of public space in winter settlements', International Journal of Biometeorology, 64, pp. 631–642. Available at: https://doi.org/10.1007/s00484-019-01852-5

Qu, H., Yuan, Q. and Leng, H. (2025) 'Spatial Optimization of Urban Green Space in Winter Cities Based on Children's Behavioral Psychology', Industrial & Engineering Design, 7(3), pp. 54-62. Available at: https://doi.org/10.19798/j.cnki.2096-6946.2025.03.007