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Usability Assessment of House-Type Shelters in Austrian Forest and Nature-Based Children's Groups: A Case Study

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Abstract

Forest and nature-based children's groups in Austria prioritize outdoor learning but rely on small "house-type" shelters for changing, meals, and stays during inclement weather. Despite the central role in daily operations, no systematic, standards-based evaluation of these shelters has been reported in the peer-reviewed literature. To address this gap, a standardized risk assessment tool—grounded in Austrian laws, technical standards, and insurer guidance—was developed and applied to ten shelters across nine groups (spring 2025). This represents, to our knowledge, the first empirical benchmarking of house-type shelter compliance against established safety, ergonomic, and usability requirements for this setting. The assessment covered 10 functional domains and three risk levels (low, medium, and high). Associations between compliance and shelter characteristics (floor area per child, total area, operator, building type) were examined using Spearman correlations and Kruskal–Wallis tests ($\alpha = 0.05$). Findings revealed frequent deviations from current standards, with implications for accident risk and staff ergonomics. Key shortcomings included insufficient room height (60.7% of rooms < 2.5 m), sub-minimum door height (60% < 2.0 m) with absent finger-pinch protection (89.7%), and inadequate daylighting (68.8% of rooms below the 12% floor-area threshold). Additional hazards involved child-height openable windows posing head-impact risks (68.8%) and lacking safety locks (100%), sharp stair edges (80%), and missing or inadequate handrails (adults 90%; children 70%). Further gaps were insufficient smoke detection (60% of buildings; 50% of rooms), inaccessible switch heights (100% of rooms > 85 cm), and furnishing deficits (coat-hook spacing: 75% < 30 cm; adult seating: 83.3% undersized; adult tables: 80% absent). No statistically significant associations were detected between compliance and shelter characteristics. However, descriptive trends suggested higher compliance in shelters with more spacious layouts and those operated by private entities. Deviations were classified by retrofit effort: low-effort, high-impact retrofits (e.g., finger guards, window restrictors, compliant handrails, stair edge rounding, and networked smoke detectors) can rapidly reduce risk. Structural modifications (e.g., room and door heights, daylighting, switch accessibility) require early consideration during planning or may necessitate special-use permits. The assessment tool and the empirical deviation profile provide a transferable, evidence-based framework to guide upgrades and design decisions, balancing pedagogical aims with safety, ergonomics, and social sustainability. By addressing a critical research gap in the built infrastructure of forest and nature-based children's groups, this study offers a replicable methodology and first actionable benchmarks for practitioners, planners, and regulators.

Check for updates

Academic Editor: Ralph Hansmann

Received: 24 June 2026
Revised: 17 September 2026
Accepted: 19 September 2026
Published: 28 September 2026

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Keywords: outdoor education; shelter; forest and nature kindergarten; occupational safety; usability; ergonomic

1. Introduction

Forest and nature-based children's groups adopt an educational approach that prioritizes regular nature exposure, with most out-of-home childcare time spent outdoors. Beyond nature education, the model emphasizes fostering children's independence while avoiding overprotection [1,2]. Outdoor learning has a positive impact on physical and mental health and supports creative, self-directed learning. It also strengthens awareness of nature and its processes, as well as social competence [1]. Daily outdoor play encourages diverse physical activities, and children in these settings often show more advanced motor skills than peers without regular nature play. Children's social skills, attention span, creativity, and imagination are also promoted [3].

Outdoor play areas with natural elements provide opportunities for risky play and for developing risk awareness [1,2]. Learning from risky situations fosters realistic self-assessment of hazards and the ability to manage them [4]. Striking an appropriate balance between risk and safety is essential. However, this is challenging when safety regulations, parental expectations, and pedagogical aims conflict. A comprehensive risk assessment can reduce this uncertainty among educators and support the implementation of free and risky play in forest and nature-based children's groups [5].

These groups typically rely on a shelter for changing clothes, having snacks, or spending time indoors during inclement weather. Shelters should provide sufficient space to comfortably accommodate all children and caregivers. At the same time, the shelter should not be overly spacious so as to avoid prolonged indoor stays that would undermine the outdoor education concept [6].

In Austria, the most common shelter type for these groups is a "house-type shelter." Other common options include "construction trailers", "tipis", and repurposed "construction containers" [7]. House-type shelters generally offer a longer service life and more space than alternative shelter types [7]. They also enable the revitalization of existing structures, such as former forest huts or farm infrastructure (e.g., barns). Repurposing existing buildings yields ecological and social benefits by utilizing existing building stock, preserving structures, and creating regional income opportunities for owners [8,9].

A substantial body of research has examined occupational health and safety in conventional childcare settings. Common hazards include high noise levels and psychosocial stress, accident risks—particularly falls—and exposure to communicable and infectious diseases [10–12]. Poor spinal alignment leading to back and neck pain is a well-documented health risk among early childhood educators, frequently linked to the absence of adult-height furniture and prolonged use of child-sized work surfaces [10–12]. Recent studies confirm that musculoskeletal disorders remain the most prevalent occupational health complaint in this sector, with inadequate workplace ergonomics consistently identified as a key contributing factor [10,11]. For forest and nature-based children's groups specifically, outdoor activity introduces additional hazards, such as increased UV exposure and risks from unstable branches and tree stumps [13]. Furthermore, international research on outdoor learning environments highlights that the physical design and quality of educational spaces significantly influence both children's safety and the pedagogical outcomes of nature-based programs [1,2,5].

Several studies have examined the pedagogical foundations of outdoor and forest-based education [1–5], and a growing body of literature addresses occupational health in

conventional childcare settings [10–12]. However, this literature focuses almost exclusively on either the pedagogical rationale for outdoor education or the occupational health of educators in standard indoor facilities. The built environment of the shelters that forest and nature-based groups rely on daily—their structural quality, usability, and compliance with safety standards—has received very limited scientific attention. To the best of the authors' knowledge, no peer-reviewed study has systematically assessed the built environment of shelters used by forest and nature-based children's groups against established safety, ergonomic, and usability standards. This gap is particularly significant because these shelters are often repurposed buildings—such as former agricultural structures or forest huts—that were not originally designed for childcare use and may therefore harbor specific structural deficiencies, safety risks, and ergonomic shortcomings that purpose-built facilities would not present [7–9]. Against this backdrop, this study examines the usability of house-type shelters and seeks to establish a foundation for their systematic evaluation. Its overarching goal is to improve the usability of existing and future shelters for forest and nature-based children's groups and to provide a basis for a standardized risk assessment for this shelter type.

Specifically, this study addresses the following research questions:

RQ1. *What are the most frequent deviations from current Austrian safety standards, guidelines, and recommendations in existing house-type shelters used by forest and nature-based children's groups—particularly regarding accident hazards, ergonomic strain, and usability for children and caregivers?*

RQ2. *Are shelter characteristics—specifically floor area per child, total floor area, sponsoring organization, and building type—associated with the degree of compliance with these standards?*

RQ3. *Which identified deviations can be addressed through low-effort retrofits, and which require consideration at the planning and design stage?*

2. Materials and Methods

2.1. Material Selection and Characteristics

As of 2023, there were 79 forest and nature-based children's groups in Austria [7]. For the study, groups using the "house" shelter type were selected based on institutional lists and direct contact. Data collection took place between April and June 2025 during on-site visits. The sample of ten shelters from nine groups (n = 10) is small relative to the total population; this reflects both the limited time frame available for on-site data collection and the considerable time required for each detailed evaluation. The resulting sample size constrains statistical power—particularly for the inferential analyses reported in Section 3.2—and limits the generalizability of the findings to the full diversity of shelter types and conditions across Austria. These constraints are addressed further in the Discussion (Section 4).

Despite this limitation, the sample was purposively composed to capture heterogeneity in size, structural design, and infrastructure. Sponsoring organizations included private associations (5/10, 50%), the municipalities (3/10, 30%), and churches (2/10, 20%).

On average, each group had two caregivers and 17 children. The mean floor area per child was 2.59 m^2, and the mean total floor area per shelter was 43.04 m^2. Three structural layouts were distinguished: (a) a single room with a separate outdoor composting toilet; (b) a single room with an attached toilet (composting or flush) directly adjacent to the building; and (c) two to three rooms with a bathroom containing a flush toilet.

2.2. Assessment Tool Development

The risk assessment instrument was developed through a two-stage process. First, a comprehensive inventory of applicable requirements was compiled from Austrian building codes [14–16], occupational safety standards [17,18], and the guidance documents of the Austrian Workers' Compensation Board (AUVA) [19] and the Social Insurance for Agriculture, Forestry, and Horticulture (SVLFG) [20]. These sources define the legally and normatively required state of the art for publicly accessible childcare settings with respect to structural safety, usability, ergonomics, accessibility, and efficient work organization.

Second, the inventory was adapted into a structured assessment form. The instrument builds on an existing draft assessment tool for the "construction trailer" shelter type maintained by the Institute of Agricultural Engineering at the University of Natural Resources and Life Sciences, Vienna. The institute uses this assessment form to conduct standardized safety evaluations of these types of shelters in nature and on farms. It was expanded to address requirements specific to the "house" shelter type.

The criteria were developed based on two complementary considerations: first, fundamental safety requirements for publicly accessible childcare facilities as established by Austrian legislation, technical standards (ÖNORM), and insurer guidance; second, the realistic feasibility of assessing and implementing these requirements in existing buildings not originally designed for childcare use. Safety relevance determined which criteria were included, while implementability guided how assessment thresholds were set. Where the two considerations conflicted, safety relevance took precedence. For example, room height is difficult and costly to modify in an existing building, yet it was included in the assessment form because substandard room height occurs often in this shelter population and constitutes a fundamental regulatory requirement [14].

The expanded assessment form was reviewed for content validity, completeness, and practical applicability by the co-authors (E.Q. and B.S.), who hold expertise in agricultural engineering, occupational safety and ergonomics, and applied statistics. E.Q.'s expertise further includes the development and field application of a prototype shelter assessment for farm-based childcare groups (ages 1–3) at a farm in Carinthia as an independent initiative, in compliance with Austrian public-law requirements and high-usability design principles.

The review process involved independent evaluation of each item against its regulatory source and iterative refinement of item wording, measurement instructions, and decision rules. To ensure the reproducibility of the results and the practical usability of the assessment form by non-professional evaluators, the evaluation criteria were supplemented with detailed instructions and descriptions. Each item includes a standardized measurement or inspection procedure, required tools, and explicit compliance/non-compliance thresholds derived directly from the referenced norms. However, no formal psychometric validation—such as inter-rater reliability testing, internal consistency analysis (e.g., Cronbach's alpha), or test–retest reproducibility—was conducted prior to field deployment. All assessments in the present study were conducted by a single trained evaluator following the standardized protocols described above, which ensures intra-rater consistency but does not permit estimation of inter-rater agreement. This constitutes a methodological limitation of the study, which is discussed in Section 4. The current results should therefore be interpreted as a first exploratory benchmarking rather than as definitive prevalence estimates.

2.3. Domains and Risk Classification

The criteria were organized by functional domain and classified into three risk levels (low, medium, and high) according to their hazard potential. The risk classification followed the hazard assessment guidance of the Social Insurance for Agriculture, Forestry, and Horticulture [20]. The assessed domains were as follows:

- Escape routes;
- Non-structural preventive measures (emergency plans, first aid, etc.);
- Stairs and safety railings (indoor/outdoor);
- Changing room;
- Common room;
- Restrooms/sanitary facilities;
- Kitchen;
- Oven/heating system;
- Outdoor entrance area;
- Terrace.

The assessment form includes items relating to organizational and procedural aspects—such as the existence of emergency plans, first aid procedures, or agreed-upon safety routines—that cannot be determined through structural observation alone. For these items, the on-site evaluator consulted the caregivers present during the visit to obtain the required information. These consultations were integral parts of completing the assessment form rather than separate, stand-alone interviews. Accordingly, no independent interview protocol, qualitative coding, or thematic analysis was applied. Facilities received verbal feedback on identified deficiencies at the end of each visit.

2.4. Data Evaluation

For each evaluation criterion, the percentage of requirements met or not met was calculated using Microsoft Excel (Version 2019). Criteria with fewer than three observations were excluded from the statistical analysis. Data processing was conducted in RStudio (Version 4.0.4, 32 bit). If less than 50% of the observations met the requirements—and thus indicated non-compliance with specifications or a potential deviation—the criteria were classified as having a particularly high deviation from the current state of technology.

2.5. Statistical Analysis

Associations between compliance and shelter characteristics were tested using Spearman rank correlations for continuous variables (floor area per child, total floor area) and Kruskal–Wallis tests for categorical variables (sponsoring organization, building type) at $\alpha = 0.05$.

Throughout this manuscript, two distinct quantities are reported and are consistently denoted by different symbols: n refers exclusively to the number of assessed shelters (the unit of analysis; $n = 10$), whereas k refers to the number of assessment items (criteria) underlying a given calculation.

The full assessment form comprised k = 88 items. For inferential analysis, only items meeting two conditions were retained: (a) mixed responses across shelters (i.e., not uniformly compliant or non-compliant across all ten shelters), and (b) complete data for all ten shelters. Items not applicable to certain buildings (e.g., stair-related criteria in single-level shelters) were excluded. This procedure yielded k = 30 analyzable assessment items spanning most assessed domains, which formed the basis of the correlation and group-comparison analyses. For each of the ten shelters, a single shelter-level compliance score was then computed as the proportion of these k = 30 items rated compliant. As a result, all inferential analyses and both Figures 1 and 2 are based on ten observations ($n = 10$ shelters). The value 30 denotes the number of assessment items contributing to each shelter's compliance score and does not represent a sample size.

Given the small sample size ($n = 10$ shelters), the statistical power of these tests is limited, and the probability of detecting true associations—should they exist—is low. The inferential results are therefore exploratory in nature. Non-significant p-values should not

be interpreted as evidence of the absence of an association but rather as inconclusive given the available data. Non-significant trends are reported in Section 3.2 and interpreted with appropriate caution in Section 4.

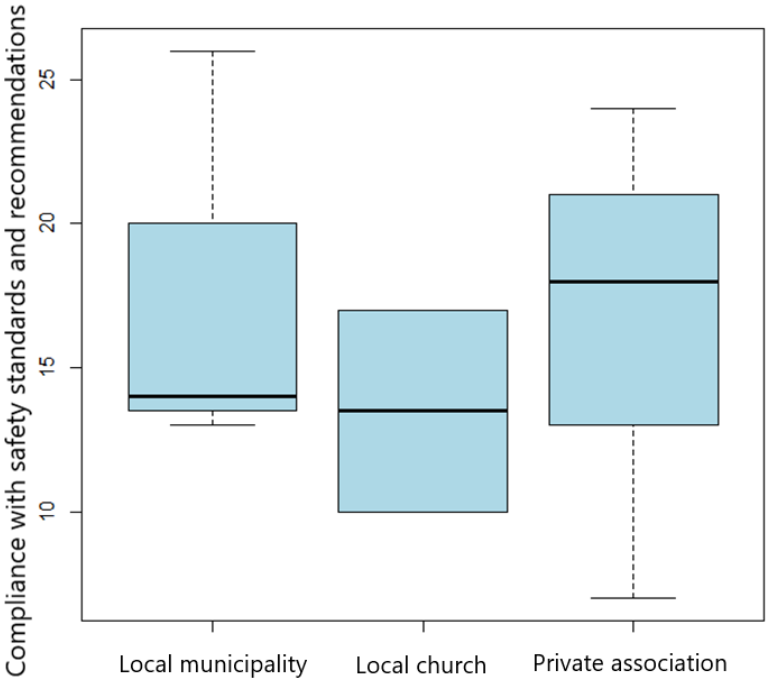

Figure 1. Degree of compliance with usability requirements by sponsoring organization (n = 10 shelters; 2025). Compliance scores were calculated from k = 30 assessment items per shelter. Shelters operated by private associations tended to show higher compliance scores than those operated by municipalities or churches; this difference was not statistically significant (Kruskal–Wallis, p = 0.7181).

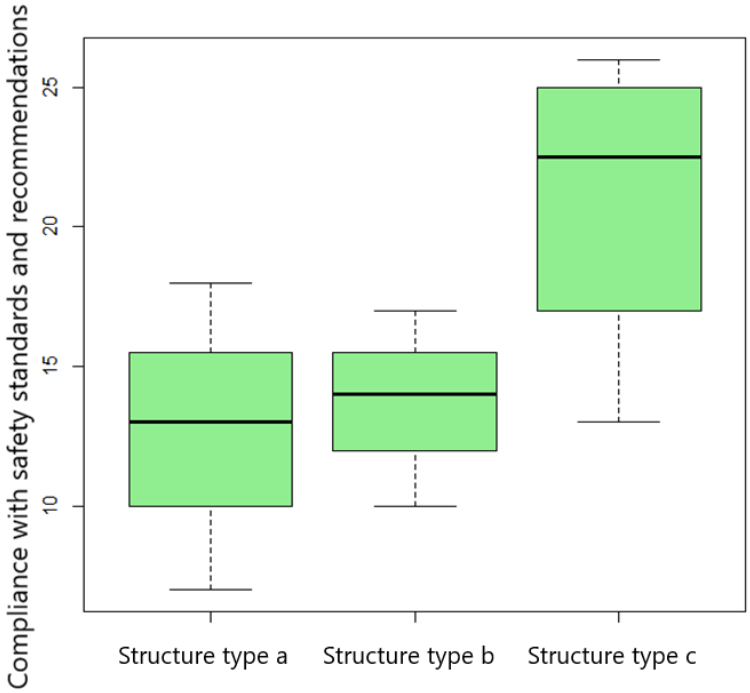

Figure 2. Degree of compliance with safety standards, recommendations, and requirements by building type (n = 10 shelters; 2025). Compliance scores were calculated from k = 30 assessment items per shelter.

3. Results

3.1. Key Deviations of Shelter Elements from Current Standards and Recommendations

Across the ten evaluated house-type shelters, systematic deviations from current safety and usability standards were identified in multiple functional domains. The risk assessment tool comprised a total of 88 individual criteria, of which the 15 criteria with the highest deviation rates (<50% compliance) are presented in Table 1. Column 3 ("Observations") specifies, for each of these 15 criteria, the number of non-conforming cases relative to the total number of assessments conducted (k = 88 in *n* = 10 shelters).

Table 1. Most frequent key deviations of shelter elements from current standards and recommendations—selection of 15 criteria with <50% compliance (out of 88 total criteria assessed (k = 88), *n* = 10 shelters, 2025).

Area	Specification (Criteria with <50% Compliance)	Observations [1]	Percentage (%)
Room height	Room height < 250 cm	17 out of 28	60.7
Door safety	Door height < 200 cm	18 out of 30	60
	Lack of finger protection	26 out of 29	89.7
Windows	Insufficient natural daylight	11 out of 16	68.8
	Potential risk of injury from open windows	11 out of 16	68.8
	Lack of child safety locks	3 out of 3	100
Stairs	Sharp edges on steps	8 out of 10	80
	Lack of handrails for adults	9 out of 10	90
	Lack of handrails for children	7 out of 10	70
	Inadequate fall protection	7 out of 10	70
Electrical installations	Insufficient number of smoke detectors	6 out of 10	60
	Light switch not at an accessible height	17 out of 17	100
Furnishing	Distance between coat hooks for children < 30 cm	9 out of 12	75
	Seating area for adults < 1520 cm^2	5 out of 6	83.3
	Lack of tables for adults	8 out of 10	80

[1] Table 1 displays the 15 criteria with the highest deviation frequency (<50% compliance); the complete list of all k = 88 assessment criteria is available from the authors upon request.

These results illustrate that safety- and ergonomics-related deviations occur in various structural and functional areas and affect both accident risks and ergonomic strain for children and childcare staff. Variation in the number of observations is attributable to the diverse construction and design of the buildings. Reported values encompass all instances per assessed criterion across functional areas (e.g., indoor and outdoor stairs).

3.1.1. Room Height

The minimum room height in workplaces and public buildings (the clear distance between the top edge of the floor and the underside of the ceiling) is 2.50 m [14]. Overall, roughly three-fifths (17/28) of assessed rooms were below this threshold, including four-fifths (8/10) of the restrooms and three-fifths (6/10) of the common rooms. Workshops and kitchens each showed one-half non-compliance (1/2), and one-quarter (1/4) non-compliance was found in changing rooms. The mean clear height across all rooms was 2.45 m (SD 0.35), with restrooms the lowest at 2.36 m (SD 0.14), which is concerning given the intensive use by children and staff.

3.1.2. Door Safety

Doors in publicly accessible buildings require a clear height of at least 2.00 m [16], and the AUVA recommends finger-pinch protection on all doors in childcare settings [19]. Across 30 door observations, more than one half (18/30) were below 2 m, and nearly nine-tenths (26/29) lacked finger-pinch protection. By location, three-fifths (6/10) of front doors

and seven-tenths (7/10) of restroom doors or doorways were below the minimum height. Finger protection was absent on all front (10/10) and restroom (9/9) doors. In common rooms, four-fifths (4/5) of doors were below the height threshold, and three-fifths (3/5) lacked finger protection. Workshop and changing room doors met the height minimum, but finger protection was missing in one-half (1/2) and all (2/2), respectively. The one kitchen door recorded in the sample failed both requirements.

3.1.3. Windows

Light-entry surfaces must total at least 12% of the floor area [15]. Overall, 11 out of 16 (11/16) rooms assessed (excluding restrooms and bathrooms) fell below this threshold. 16 rooms had windows at children's height that preschoolers could open without built-in locking mechanisms. These included windows in three-fifths (6/10) of common rooms, all kitchens and changing rooms (2/2 each), and one-half (1/2) of workshops.

Openable windows at children's height must not pose hazards to children [19]. Overall, 16 rooms across the assessed shelters had such windows without built-in locks, and eleven-sixteenths (11/16) presented head-impact risks due to sashes projecting into the room when open. These hazards occurred in four-fifths of all common rooms (8/10). This deficiency was also found in one quarter (1/4) of restrooms, one half (1/2) of kitchens, and all (1/1) assessed changing rooms.

Windows with handles within a child's reach and an exterior fall height $\geq$ 2 m must be equipped with a child safety lock [19]. In the assessments, three such cases were identified, and none had locks: two in common rooms and one in a kitchen.

3.1.4. Stairs

To ensure that stairs are safe and suitable for use, steps must not have sharp edges. Corners and edges must therefore be rounded to a radius of 2 mm to prevent serious injuries if children slip on them or climb on them [19]. Overall, four-fifths (8/10) of all documented staircases had sharp edges and pointed corners. Non-compliance was found at all entrances (6/6) and on all terraces (2/2).

Handrails for adults on staircases must be installed on both sides at a height of 85 to 90 cm [14]. Childcare facilities should provide children's handrails at 60 to 80 cm [19]. Adult handrails were missing or incorrectly installed on nine-tenths (9/10) of staircases—one-half indoors (1/2) and all at entrances (6/6) and on terraces (2/2). Children's handrails were missing or inadequate in seven-tenths (7/10). These were exclusively outdoors: all outdoor stairs (6/6) and half of the terrace stairs (1/2).

3.1.5. Electrical Installations

Networked smoke detectors are required in all common areas and hallways of child-care facilities [16]. In our sample, three-fifths (6/10) of buildings lacked a sufficient number of detectors; two-fifths (4/10) had none, one-half (5/10) had one, and one-tenth (1/10) had two. At the room level, one-half (8/16) of the assessed rooms were not equipped with a smoke detector.

Light switches should be installed at an accessible height of 85 cm, which is generally reachable by children [21]. All rooms with switches failed to reach this standard (17/17). The average mounting height was 119.6 cm (SD 15.3); they were installed 34.6 cm above the recommended target.

3.1.6. Furnishing

The distance between coat hooks in children's racks should be at least 30 cm [17]. Although hook height was correct in all cases, minimum spacing was not met in three-

quarters (9/12)—five-sevenths indoors (5/7) and four-fifths outdoors (4/5). Mean spacing was 20.8 cm (SD 7.33), i.e., 9.17 cm below the standard.

Most facilities provided adult-height seating, but five-sixths (5/6) of seats had undersized surfaces relative to the recommended ~40 × 38 cm (~1520 cm^2) [18]. The mean seat area was 1228.23 cm^2 (SD 272.7), a shortfall of 291.7 cm^2. Seating comprised height-adjustable stools (3/6), simple chairs (2/6), and one folding chair (1/6); four-fifths (8/10) of facilities lacked an adult table.

3.2. Associations Between Shelter Characteristics and Compliance with Usability Standards

Associations between compliance and shelter characteristics (floor area per child, total floor area, sponsoring organization, and building type) were tested using each shelter's compliance score derived from the k = 30 analyzable assessment items (Section 2.5). No statistically significant associations were detected for any of these characteristics at $\alpha = 0.05$ (Tables 2 and 3).

Table 2. Spearman rank correlations between shelter-level compliance and continuous shelter characteristics (total floor area, floor area per child) (n = 10 shelters; compliance scores[2] based on k = 30 assessment items, 2025).

Shelter Characteristic	Correlation (Area per Child)	*p*-Value	Correlation (Total Area)	*p*-Value
Total floor area	0.395	0.258	-	-
Floor area per child	-	-	0.182	0.614

Compliance scores were calculated as the proportion of compliant items among the k = 30 analyzable assessment items per shelter; n = 10 shelters. $\alpha = 0.05$.

Table 3. Kruskal–Wallis tests of shelter-level compliance by building type and sponsoring organization (n = 10 shelters; compliance scores[2] based on k = 30 assessment items; 2025).

Variable	*p*-Value
Sponsoring organization	0.718
Building type	0.188

Compliance scores were calculated as the proportion of compliant items among the k = 30 analyzable assessment items per shelter; n = 10 shelters. $\alpha = 0.05$.

The Spearman rank correlations indicated no statistically significant association between shelter-level compliance and total floor area ($p = 0.6141$; $\rho = 0.1824$) or floor area per child ($p = 0.2584$; $\rho = 0.3951$). Likewise, the Kruskal–Wallis tests revealed no statistically significant differences in compliance by building type ($p = 0.1878$) or by sponsoring organization ($p = 0.7181$). All tests were based on ten shelter-level observations (n = 10).

Given the small sample size (n = 10 shelters), these tests have limited statistical power; the non-significant results should therefore be interpreted as inconclusive rather than as evidence of the absence of an association. Despite the non-significant results, certain descriptive trends were observed.

A larger area per child and a larger total area of the shelter were associated with a higher degree of compliance with standards. Descriptively, shelters with a larger floor area per child and a larger total floor area tended to achieve higher compliance scores, although these associations were not statistically significant.

Figures 1 and 2 show the degree of compliance by sponsoring organization and building type, respectively (n = 10 shelters). Compliance scores were calculated from k = 30 assessment items per shelter.

More spacious buildings (building type C) showed a higher degree of compliance than more compact buildings (building types A and B). These trends warrant investigation in larger samples.

4. Discussion/Limitations

The developed risk assessment form aligns with established evidence on childcare hazards, explicitly addressing accident risks, ergonomic strain, and hygiene-related issues identified as key risks in childcare settings [10–12]. Other relevant key risk factors, such as psychosocial stress and noise, were only partially covered due to the instrument's structural focus and its emphasis on preventive measures.

4.1. Low-Effort, High-Impact Retrofits

Several deviations can be mitigated through cost-effective retrofits that are feasible in existing shelters and yield immediate safety benefits. Many indoor staircases—and none of the outdoor staircases—had defect-free, correctly positioned handrails for adults or children; retrofitting compliant handrails indoors and outdoors is straightforward and should be prioritized given children's elevated fall risk [22].

Installing finger-pinch protection on doors—available for standard, sliding, and hinged doors—reduces crush and laceration risks at hinge and closing edges and can be fitted retrospectively without major structural work.

Window restrictors or tilt-only hardware should be fitted to child-height, openable windows to limit sash travel. This prevents head impact hazards from inward-projecting sashes and reduces the risk of children climbing and falling, while preserving ventilation. These solutions are widely applicable across window types and can be installed with minimal intrusion.

Networked smoke detectors should be installed across common areas and corridors to ensure early, building-wide alarm transmission. This is particularly important in multiroom shelters, and devices can be added to ceilings or walls at any time without structural intervention, facilitating rapid upgrades in existing buildings.

The frequent use of homemade and natural materials (e.g., wooden hooks, handcrafted stairs) in these settings likely underpins the observed deficiencies in hook spacing and unrounded stair and hook edges [6]. Smoothing edges and repositioning or replacing hooks can be implemented with minimal effort and may reduce injury risk, particularly from falls, which are prevalent in childcare environments [22].

Collectively, these retrofits address high-risk hazards identified in the assessments—finger injuries at doors, impact and fall risks at windows and stairs, and fire and smoke exposure—while requiring comparatively low effort and cost relative to structural alterations.

4.2. Ergonomic Considerations

Adult seating was generally at an appropriate height or adjustable; however, seat surfaces frequently fell below the recommended ~40 × 38 cm (~1520 cm^2). Adult tables were available in only two of ten facilities—likely reflecting space-saving design priorities. Prolonged work without adult-appropriate seating and work surfaces (e.g., when using children's furniture) increases musculoskeletal load and is associated with back pain and long-term harm, warranting prioritization of adult-appropriate ergonomics [10–12,19]. Practical guidance supports providing suitable work heights; foldable chairs and tables offer space-efficient solutions for constrained interiors while meeting ergonomic requirements [10–12].

4.3. Structural Deviations Requiring Major Intervention

Several deviations require substantial post-construction effort and cost to achieve compliance and reduce risk. Adjusting room and door heights in existing buildings is

structurally complex and expensive and is therefore best addressed during planning and design. Ensuring sufficient daylighting is likewise most efficient at the design stage; in existing shelters, upgrades can demand considerable labor and materials, although artificial lighting can partially compensate where electricity is available. Relocating light switches to accessible heights is feasible in existing buildings but should be performed by qualified professionals to ensure compliance and safety.

These constraints are especially pronounced when repurposing existing spaces, underscoring the importance of addressing such hazards and comfort deviations early in the design of new shelters and in renovations. Accordingly, preventive efforts should prioritize frequent, high-impact issues that can be mitigated with minimal effort—particularly accident hazards and ergonomic strain (notably spinal load), as highlighted in the literature. Falls are a prevalent accident mechanism in childcare settings and further justify this prioritization [10–12,22].

4.4. Pedagogical Model Versus Spatial Requirements

The findings of this case study reveal a fundamental tension between the educational philosophy of forest and nature-based children's groups and the spatial and ergonomic conditions required for a safe, functional shelter environment. These groups intentionally prioritize time spent outdoors, encourage children's independence, and consciously avoid overprotection [1,2]. In practice, this philosophy translates into shelters that are deliberately small and designed with natural, minimalist materials—a pattern clearly evident across the sample studied here.

However, the assessment results show that this compact, minimalist approach comes at a cost. Shelters with more floor area and more spacious layouts consistently achieved higher compliance with ergonomic and usability standards, whereas smaller shelters were more likely to fall short of safety and comfort requirements. This pattern points to a clear trade-off: the smaller the shelter, the more difficult it becomes to meet basic standards for room height, daylighting, adult-appropriate furniture, and safe circulation. These findings highlight the need to provide adequate space and suitable ergonomic equipment for the protection of both children and staff—even when the pedagogical concept favors compact, nature-oriented shelters [6]. Reconciling these competing demands will require careful planning that integrates safety considerations from the earliest design stage without undermining the core educational goals of the program.

4.5. Limitations and Future Research

This study is constrained by several methodological limitations. First, the small, heterogeneous sample (n = 10) limits both statistical power and generalizability. The findings may not adequately reflect the diversity of existing shelters for forest and nature-based children's groups in Austria. Second, all assessments were conducted by a single trained evaluator. While the standardized protocols ensure intra-rater consistency, inter-rater reliability was not assessed, and no formal psychometric validation of the assessment instrument was conducted prior to field deployment. The results should therefore be interpreted as a first exploratory benchmarking rather than as definitive prevalence estimates.

To strengthen the evidence base, broader, systematic assessments of both interior and exterior areas across additional shelters are recommended to identify domains with the largest deviations from current state-of-the-art standards and to inform minimum requirements for usability, ergonomics, and safety. Such work would also enable more robust statistical analyses by ownership, structural type, total size, and area per child—information essential for defining minimum shelter size and equipment standards for forest and nature-based groups.

These efforts should be complemented by a participatory process involving educators and staff, structured in three concrete steps: (1) feedback workshops with educators and shelter operators to identify practical barriers to retrofit implementation; (2) pilot testing of the assessment tool by practitioners to evaluate usability and inter-rater reliability; and (3) integration of educator experience into the prioritization of retrofit measures, ensuring that safety improvements align with daily operational routines and pedagogical practice. Achieving sufficiently broad participation will require awareness-raising measures to embed the relevance of safety standards in everyday practice.

Finally, while the present focus on the "house" shelter type supports the sustainable development of this most common typology, future research should also examine alternative types—such as construction trailers, containers, and tipis [7]—to systematically evaluate their usability and safety and to identify targeted improvements for each typology.

Author Contributions: Conceptualization, E.Q. and A.L.; methodology, E.Q. and A.L.; software, A.L.; validation, E.Q. and B.S.; formal analysis, E.Q., B.S. and A.L.; investigation, E.Q., B.S. and A.L.; resources, E.Q. and A.L.; data curation, A.L.; writing—original draft preparation, E.Q., B.S. and A.L.; writing—review and editing, E.Q., B.S. and A.L.; visualization, E.Q., B.S. and A.L.; supervision, E.Q. and B.S.; project administration, E.Q. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study is waived for ethical review as the survey exclusively collected anonymized data on organizational aspects and building infrastructure of childcare facilities. No personal data of individual participants were gathered at any point.

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in the study.

Data Availability Statement: Due to ongoing research, raw data are not publicly available but can be requested from the corresponding author. A minimal replication dataset is archived at [https://doi.org/10.5281/zenodo.22944682] (Zenodo).

Acknowledgments: We thank the participating forest and nature kindergarten groups and their pedagogical teams for enabling the on-site data collection. During the preparation of this manuscript, the authors used Mistral Large 3 (Mistral AI, June 2024 version) for Language refinement (Abstract Section and Section 4), Translation (key passages from German to English), and Literature search support (Academic AI, Scopus AI). AI-generated or AI-assisted content—including suggested literature—was critically reviewed, edited, and validated by the authors, who take full responsibility for the final publication. The AI tools did not contribute to data collection, analysis, or interpretation. The authors reviewed and edited the content as needed and took full responsibility for the final publication.

Conflicts of Interest: The authors declare no conflicts of interest.

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