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Factor structure of the Early Childhood Environment Rating Scale – Third Edition and its association with structural quality in Swedish preschools

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ABSTRACT

The Early Childhood Environment Rating Scale, Third Edition (ECERS-3), is widely used to assess preschool quality. However, concerns remain about its scoring structure, usage in different cultural contexts, and associations with structural quality indicators. This study explored the factor structure of the ECERS-3 and its relationship with teacher education, child-to-adult ratio, group size, and preschool size in 71 Swedish municipal preschools. Confirmatory factor analysis showed poor fit for both the single-factor modeland the original six-subscale structure. Exploratory factor analysis identified a better-fitting four-factor structure: Learning & Play Environment, Interactions & Order, Gross Motor, and Care & Hygiene. We further investigated whether adopting this revised factor structure influenced relationships between ECERS-3 dimensions and structural quality indicators. Analyses of associations with structural quality indicators showed that smaller group sizes were linked to higher quality in Gross Motor activities. Among preschools with group sizes below 15 children, smaller groups were also associated with higher quality in Learning & Play Environment, Care & Hygiene, and overall ECERS-3 scores. Pedagogical and interactional dimensions showed limited or inconsistent relationships with structural variables. Future research should carefully consider how ECERS-3 scores are analyzed and be mindful of potential threshold effects when exploring associations with structural quality.

KEYWORDS

ECERS-3; process quality; structural quality; early childhood education; factor analysis

SUSTAINABLE DEVELOPMENT GOALS

SDG 4: Quality education

A central aim of early childhood education and care (ECEC) is to provide high-quality programs that support each child's development and learning. Achieving this goal requires understanding which preschool characteristics best promote these outcomes. Research identifies two main quality dimensions: **structural quality**, which includes aspects such as teacher qualification, child-to-adult ratio, group size, and preschool size; and **process quality**, which involves children's everyday experiences with materials, activities, and interactions with staff (Burchinal 2018; Eadie et al. 2024; Yoshikawa et al. 2013). One key question is how *structural quality factors* relate to *process quality factors,*

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as process quality is considered the primary mechanisms influencing child outcomes (Burchinal 2018). Process quality has been linked to a range of child developmental outcomes, such as stronger socio-emotional development and self-regulation, school readiness, and learning trajectories over time (Burchinal 2018; Burchinal et al. 2016; Von Suchodoletz et al. 2023). Understanding the link between structural quality factors and process quality factors is therefore central for strengthening ECEC, and by extension child development.

Among structural aspects of quality, teacher qualification is one of the most studied. Higher levels of teacher education are expected to equip educators with the skills needed to improve preschool quality. A recent scoping review found limited evidence for positive effects of teacher qualification (Eadie et al. 2024). A closer inspection shows that meta-reviews focusing on preschool quality outcomes report small but generally positive associations between teacher qualification and observed process quality (Manning et al. 2017; Manning et al. 2019). In contrast, meta-reviews examining child-level outcomes find weaker or non-significant associations (Falenchuk et al. 2017; Nocita et al. 2020).

Other structural factors, such as child-to-adult ratio and group size, have also received attention. Evidence for beneficial effects of smaller group sizes is generally weak, with many studies reporting null findings (e.g. Næsby and Sperling 2023; Pianta et al. 2005; Slot et al. 2015; Slot et al. 2018), although a meta-analysis found small positive effects when group sizes were below 15 children, indicating threshold effects (Bowne et al. 2017).

Evidence for positive effects of a lower child-to-adult ratio is somewhat stronger. Several studies report associations between lower ratios and higher process quality (Hestenes et al. 2019; Phillipsen et al. 1997; Vermeer et al. 2016), although others fail to find such links (Næsby and Sperling 2023; Pianta et al. 2005; Slot et al. 2015; Slot et al. 2018). Meta-analytic evidence again points to threshold effects, with stronger effects when ratios fall below 7.5:1 (Bowne et al. 2017). Overall, these findings indicate that the effects of these structural factors on process quality are modest and context dependent, highlighting the importance of considering additional structural aspects.

Preschool center size, defined as total enrolment, has been less studied. Larger centers may offer more resources and professional collaboration but could also increase child stress or reduce individual attention. Cryer et al. (1999) found in a cross-country comparison, that center size positively predicted ECERS scores in two out of three European contexts but not in the United States (U.S.). In contrast, evidence from compulsory school settings often suggests a negative association between school size and student outcomes (Egalite and Kisida 2016; Leithwood and Jantzi 2009), though the extent to which these findings generalize to preschool contexts remains unclear.

Overall, evidence supports links between structural and process quality and child outcomes. However, findings are mixed, likely due to restricted within-country variance resulting from regulatory frameworks, as well as methodological and statistical challenges related to the interrelated nature of structural characteristics.

Understanding how structural and process quality interact in influencing children's outcomes depends on reliable measures of quality. The Environment Rating Scales (ERS) are widely used internationally (Harms, Clifford, and Cryer 2015; Vermeer et al. 2016), including applications in over 30 countries, among them Sweden (Garvis et al. 2018). The latest version, *Early Childhood Environment Rating Scale – Third edition* (ECERS-3; Harms, Clifford, and Cryer 2015), is an observational instrument designed to assess multiple dimensions of

process quality in early childhood education settings. It consists of 35 items rated on a scale of 1 (inadequate) to 7 (excellent). These items form six subscales: *Space and Furnishings, Personal Care Routines, Learning Activities, Language and Literacy, Interactions and Program Structure*. The scores of the items are averaged to yield a total quality score.

To assess ECERS-3's quality as a measure, its factor structure must be better understood. Two U.S. studies have examined this using factor analysis and found poor statistical fit for both a single-factor structure, consistent with use of an average score, and the six-subscale model. Montes et al. (2018), with data from 148 urban U.S. preschools, proposed a three-factor model (Learning Activities and Environment, Interaction, and Gross Motor). Early et al. (2018), studying 1,063 classrooms, identified a better-fitting four-factor model (Learning Opportunities, Teacher Interactions, Gross Motor, and Math Activities). Similar discrepancies have also been reported for earlier versions of the ECERS (Gordon et al. 2013; Munton et al. 1997; Perlman, Zellman, and Le 2004; Scarr, Eisenberg, and Deater-Deckard 1994). These findings suggest that the published subscales may not reflect how the items cluster statistically, complicating interpretations of the link between structural and process quality. To our knowledge, the factor structure of the ECERS-3 has not been examined outside the U.S.

The present study

The research is conducted in Sweden, where ECEC is publicly funded and nearly universal (~96% of children between 3–5 attend preschool; Swedish National Agency for Education 2024a). Sweden is among the highest-spending OECD countries, both in terms of expenditure per child and as a proportion of gross domestic product (OECD 2017). The curriculum-based system for children aged one to five emphasizes play-based learning and children's agency (Swedish National Agency for Education 2019), and most of the day is spent in different forms of free play (Åström et al. 2020). All children are entitled to education delivered by certified preschool teachers. Certification requires a bachelor's degree with a specialization in early childhood education, held by approximately 41% of staff (Swedish National Agency for Education 2024a). Child–staff ratios and group sizes have been subject to non-binding national guidelines rather than formal regulations, and many preschools have operated above these recommended levels (Swedish National Agency for Education 2024a), with a national average group size of 15.3 children and an average of 5.1 children per pedagogical staff member (Swedish National Agency for Education 2024b). Nevertheless, the overall quality of Swedish ECEC is regarded as comparatively high based on structural quality measures (OECD 2017; Persson 2015).

The aim of the study is to investigate the factor structure of the ECERS-3 and its relationship with key structural quality indicators.

Specifically, we:

(1) Test four models of the ECERS-3 factor structure: (i) a single-factor model (total score), (ii) a six-factor model (ECERS-3's six subscales), (iii) a three-factor model by Montes et al. (2018), and (iv) a four-factor model by Early et al. (2018).

If no model provides a satisfactory fit to the observed data, we perform additional analyses to determine the best-fitting model.

(1) Examine associations between the resulting ECERS-3 factors and key structural variables (teacher education, child-to-adult ratio, group size, and preschool size).

Method

Study design and sample

Data were collected as part of the longitudinal PreQuEL project. The broader project follows children born between 2016 and 2018 who attended municipal preschools in Uppsala County, Sweden. It integrates registry data from Swedish Child Health Care Services, Statistics Sweden, and Uppsala Municipality with structured observations of preschool quality and assessments of learning outcomes at school entry, linked to each preschool.

For this study, structured observations of preschool quality (ECERS-3) were conducted in 71 preschools, and structural quality data were obtained from municipal registries. One randomly selected classroom (or *group* in Swedish preschool terminology) of children from 3 to 5 years of age per center was observed.

All municipal preschools in Uppsala municipality were invited to participate. Of 92 eligible preschools, 9 declined due to staff illness or shortages, 2 had no available units after parental opt-outs, 1 was in the process of closing, and 9 declined for unspecified reasons. In total, 71 preschools remained, each observed once.

Ethical considerations

This study was conducted in line with the principles of the Declaration of Helsinki and approved by the Swedish Ethical Review Authority (Etikprövningsmyndigheten; reference number 2022-04015-01). Prior to data collection, the ECERS-3 scale was piloted in three preschools to ensure feasibility and minimal disruptions to daily activities. Participation required written informed consent from preschool headmasters. Parents were informed that their child's classroom might be observed and were given the opportunity to opt out; classrooms with opt-out requests were excluded from the sampling frame. The final dataset was pseudonymized and contains no personal identifiers.

ECERS-3

Preschool quality was assessed using the Swedish translation of the ECERS-3 (Harms, Clifford, and Cryer 2015), the third edition of the Environment Rating Scale for preschools serving children aged 3–5 years. The scale is designed to measure multiple aspects of process quality. It comprises 35 items, each operationalized through 10–17 ordered, dichotomously scored (yes/no) indicators that describe increasingly higher levels of quality (e.g. 'Staff are almost always prepared for the next activity' or 'At least 15 books are available for at least 25 min during the observation').

Item scores are derived by applying ECERS-3 scoring rules to the pattern of observed indicators: indicators are first rated as present or not present, and these ratings are then used to assign a single item score on a 7-point Likert scale, where 1 indicates 'Inadequate' quality, 3 'Minimal' quality, 5 'Good' quality, and 7 'Excellent' quality. Higher item scores require that all indicators a lower level are met, along with an increasing number of indicators at the corresponding level.

The 35 items are grouped into six subscales: Space and Furnishings, Personal Care Routines, Language and Literacy, Learning Activities, Interaction, and Program Structure. The primary outcome measure is the mean score across all 35 items.

The Swedish version closely follows the original scale, with minor adaptations, such as aligning health, safety, and playground standards with Swedish regulations, as well as slight alterations in the wording of a handful of indicators.

ECERS-3 observations

Observations were conducted by two observers between December 2022 and May 2023. Observer A assessed 56 preschool groups and Observer B assessed 15 preschool groups. Each group was visited once and observed for approximately three hours ($M = 181$ min; $SD = 6$ min), typically between 8:30 and 11:30 am, on a day identified by staff as representative of usual practice. Following a brief introduction, the observer passively followed the group's activities without interfering with daily routines.

Observer training

Prior to data collection, the observers and the first author completed an introductory online ECERS-3 course provided by the Environment Rating Scale Institute. Observer A was trained through joint observations with the first author until an inter-rater agreement of at least 85% (within one point across all 35 items), in line with ECERS-3 guidelines, was achieved, after which independent observations were conducted. Observer B was recruited later and trained using the same procedure before conducting independent observations.

Structural measures

Municipality registry data on structural preschool factors were provided by the municipality and are publicly available through the Kolada database (www.kolada.se). The data are reported on the individual preschool level and reflect conditions as of October 15 in 2022, and 2023.

Teacher education

Proportion of full-time equivalent pedagogical staff holding a license to teach preschool. A licensed preschool teacher has either (1) 3.5 years of education at the university-level preschool teachers' program, (2) 5 years of teaching experience plus 2.5 years of preschool teacher education, or (3) a license granted based only on teaching experience (a rarely used option that is only available to those born before July 1, 1958).

Child-to-adult ratio

The child-to-adult ratio was operationalized as the number of enrolled children per full-time equivalent pedagogical staff member.

Group size

Group size was defined as the average number of children per preschool group (the primary group in which children spend most of their day).

Preschool size

Preschool size was measured as the average number of children enrolled in the preschool center.

Data analysis

The variables, hypotheses, and main analyses were registered before data analysis began (https://osf.io/6cr59). Two ECERS-3 items permit an NA response when the activity is not observed; consequently, these items contained missing data. Item 27 ('Appropriate use of Technology') was excluded due to its high proportion of missing data (52%). Item 35 ('Whole-group activities for play and learning') had 4 missing data points (6%) and was retained, with missing data addressed using multiple imputation. Twenty imputations were employed, and the mode of the imputed values was used in subsequent analyses. Retaining the missing values did not affect subsequent findings. Structural data contained minimal missing values, which were retained without imputation. However, to account for potential inaccuracies in municipal reporting, outliers exceeding two standard deviations from the mean (9 instances; 3.2% of observations) were adjusted by trimming them to the nearest non-outlier value.

After descriptive analysis, three main analyses were conducted:

(1) Confirmatory factor analysis to test the fit of four ECERS-3 factor structures – a one-factor total mean score model, a six-factor subscale model, a three-factor model by Montes et al. (2018), and a four-factor model by Early et al. (2018).
(2) Exploratory factor analysis followed by confirmatory factor analysis to determine the best-fitting factor structure for the sample and compare its fit to the other models.
(3) Simple regression analysis to examine the associations between each structural quality variable (teacher education, child-to-adult ratio, group size, and preschool size) with the best-fitting ECERS-3 factor model and total mean score.

For model fit, we followed published guidelines, defining a root mean square error of approximation (RMSEA) $< .05$ and a comparative fit index (CFI) $> .9$ as indicators of good fit (Hu and Bentler 1999; Sivo et al. 2006). Assumptions of factor analysis were fulfilled. Unlike previous ECERS-3 confirmatory factor analyses, we treated item scores as ordinal rather than continuous, consistent with their Likert-scale nature. Consequently, we used weighted least squares mean and variance-adjusted (WLSMV) estimation when estimating confirmatory factor analyses. Residual plots and Q-Q plots reveal approximate homoscedasticity and close to normally distributed residuals for all simple regressions.

Results

Descriptive statistics

Descriptive statistics for each ECERS-3 item and their correlations with the total mean score are presented in Table 1. The distribution of item scores is shown in the online supplementary material (Fig. SI1). All but six items were significantly

Table 1. Descriptive statistics of ECERS-3 items and correlation with ECERS-3 mean score.

	Item	Valid	Mean	SD	Min.	Max.	Corr. Mean
	Space and furnishings (SF)	71	3.67	0.80	2.00	5.29	.66***
1	Indoor space	71	4.06	1.76	1	7	.49***
2	Furnishing for care, play and learning	71	3.72	1.10	1	6	.4***
3	Room arrangement for play and learning	71	3.35	1.48	1	7	.4***
4	Space for privacy	71	3.15	0.91	1	6	.48***
5	Child-related display	71	3.30	1.74	1	7	.32**
6	Space for gross motor play	71	4.07	1.62	1	7	.23*
7	Gross motor equipment	71	4.01	1.76	1	7	.23
	Personal care routines (PCR)	71	3.20	0.91	1.25	6.00	.56***
8	Meals/snacks	71	2.31	1.13	1	6	.29*
9	Toileting/diapering	71	3.14	1.28	1	6	.5***
10	Health practices	71	2.96	1.69	1	7	.36**
11	Safety practices	71	4.41	1.52	1	7	.32**
	Language and Literacy (LL)	71	3.28	0.79	1.40	5.00	.72***
12	Helping children expand vocabulary	71	2.94	1.09	1	6	.41***
13	Encouraging children to use language	71	3.94	1.42	1	7	.59***
14	Staff use of books with children	71	2.49	1.61	1	6	.36**
15	Encouraging children's use of books	71	2.94	1.23	1	6	.36**
16	Becoming familiar with print	71	3.07	1.23	1	6	.44***
	Learning Activities (LA)	71	2.34	0.48	1.45	3.36	.70***
17	Fine motor	71	3.32	1.43	1	6	.34**
18	Music and movement	71	3.39	1.32	1	7	.45***
19	Art	71	1.94	0.54	1	3	.22
20	Blocks	71	1.65	0.91	1	4	.15
21	Dramatic play	71	2.07	1.19	1	5	.5***
22	Nature/science	71	2.42	1.01	1	4	.23*
23	Math materials and activities	71	1.80	1.07	1	5	.32**
24	Math in daily events	71	2.66	1.35	1	6	.23
25	Understanding written numbers	71	1.77	0.88	1	5	.38**
26	Promoting acceptance of diversity	71	2.17	1.02	1	5	.10
27	Appropriate use of technology	34	2.82	1.45	1	6	.22
	Interaction (I)	71	3.97	0.97	1.40	5.60	.76***
28	Supervision of gross motor	71	3.80	1.60	1	7	.24*
29	Individualized teaching and learning	71	3.45	1.24	1	6	.56***
30	Staff–child interaction	71	4.32	1.75	1	7	.68***
31	Peer interaction	71	4.30	1.22	1	7	.56***
32	Discipline	71	3.97	1.21	1	7	.63***
	Program structure (PS)	71	3.60	1.03	1.33	6.00	.76***
33	Transition and waiting times	71	3.68	1.91	1	7	.41***
34	Free play	71	2.63	1.14	1	5	.65***
35	Whole-group activities for play and learning	67	3.55	1.41	1	7	.62***
	ECERS-3 mean scores	71	3.19	0.52	2.03	4.09	–

Note: 'Corr. Mean' is the correlation between individual item scores and the average of all items., * $p < .05$, ** $p < .01$, *** $p < .001$.

correlated with the total mean score. The items that were not significantly correlated related either to gross motor equipment and space or to low-scoring items within the Learning activities subscale. The internal consistency of the scale was adequate, with a Cronbach's alpha of .83. Removing any single item did not meaningfully change the reliability estimate.

The mean ECERS-3 score was 3.19 ($SD = 0.52$), equivalent to a level of *minimal quality* according to the scoring guide. The lowest scores were observed in the Learning Activities subscale ($M = 2.34$), with Blocks being the lowest-scoring individual item ($M = 1.65$). In contrast, the highest-scoring subscale was Interaction ($M = 3.97$), and the highest-scoring item was Safety Practices ($M = 4.41$).

Descriptive statistics for the structural quality variables in preschools are displayed in Table 2.

Table 2. Descriptive statistics for structural quality variables.

	Mean	SD	Min	Max
Teacher Education	0.41	0.08	0.26	0.28
Child-to-adult Ratio	5.53	0.54	4.38	6.44
Group Size	15.44	2.52	10	21
Preschool Size	75.27	29.70	16	139

Note: Values represent the average of measurements recorded on October 15 in 2022 and 2023. Teacher Education = Proportion of staff that are licensed preschool teachers, Child-to-adult Ratio = Number of children per full-time employee, Group size = Average number of children per group, Preschool Size = Total number of children enrolled in preschool.

Confirmatory factor analysis

Confirmatory factor analyses (CFAs) were conducted to evaluate the fit of previously published ECERS-3 factor structures. The one-factor model, which assumes a unidimensional structure based on the mean score of all items, demonstrated poor fit, RMSEA = .09, 90% CI [.08, .11], CFI = .62, $\chi^2[495] = 798.70$, $p < .001$.

The six-factor model specified in the ECERS-3 manual failed to converge because the covariance matrix of the latent variables was not positive definite. Sequentially removing each factor revealed that the Program Structure subscale was the source of the estimation problem. Excluding this subscale allowed the model to converge; however, model fit was poor, RMSEA = .09, 90% CI [.08, .11], CFI = .64, $\chi^2[424] = 678.91$, $p < .001$. Together, these results indicate that neither the one-factor nor the six-factor model provided an adequate representation of the data.

We next tested alternative models previously identified in U.S. samples. The three-factor model reported by Montes et al. (2018), consisting of Learning Activities and Environment, Interaction, and Gross Motor, did not meet the fit criteria, RMSEA = .08, 90% CI [.06, .10], CFI = .80, $\chi^2[204] = 303.42$, $p < .001$), suggesting a different factor structure in the present sample. The four-factor model proposed by Early et al. (2018), comprising Learning Opportunities, Teacher Interactions, Gross Motor, and Math Activities, also failed to meet the fit thresholds, RMSEA = .07, 90% CI [.05, .08], CFI = .88, $\chi^2[318] = 414.45$, $p < .001$. However, the RMSEA and CFI values suggested a comparatively better fit than previous models.

Exploratory factor analysis

Given the inadequate fit of the tested confirmatory models, an exploratory factor analysis (EFA) was conducted. Bartlett's test of sphericity was significant, $\chi^2(561) = 1022.17$, $p < .001$, indicating that the correlation matrix was suitable for factor analysis. The overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .59, indicating marginal adequacy for factor analysis with the implication that the model should be interpreted with caution. Maximum likelihood extraction and promax rotation were used. Parallel analysis based on eigenvalues and inspection of the scree plot supported a four-factor solution. The model showed acceptable fit, $\chi^2(431) = 469.71$, $p = .096$, and accounted for 35.6% of the total variance. Items with factor loadings of .40 or higher were retained for interpretation. Cross-loadings were evaluated for loadings above .30 and no included items showed substantial cross loadings. The resulting factors were labeled: *Learning & Play Environment, Interactions & Order*, *Gross Motor*, and *Care & Hygiene* (see Table 3).

Table 3. Exploratory factor analysis of ECERS-3 items.

Item	Factor 1 (Learning & Play Environment)	Factor 2 (Interactions & order)	Factor 3 (Gross motor)	Factor 4 (Care & hygiene)	Communality
2 Furnishing for care, play and learning	0.84				0.61
29 Individualized teaching and learning	0.63				0.51
17 Fine motor	0.62				0.46
3 Room arrangement for play and learning	0.61				0.37
21 Dramatic play	0.51				0.37
34 Free play	0.50				0.50
15 Encouraging children's use of books	0.48				0.27
4 Space for privacy	0.48				0.35
18 Music and movement	0.47				0.30
14 Staff use of books with children	0.47				0.20
31 Peer interaction		0.74			0.58
32 Discipline		0.73			0.65
30 Staff–child interaction		0.71			0.64
13 Encouraging children to use language		0.69			0.55
33 Transition and waiting times		0.53			0.28
35 Whole-group activities for play and learning		0.49			0.43
12 Helping children expand vocabulary		0.40			0.20
6 Space for gross motor play			0.80		0.68
7 Gross motor equipment			0.80		0.64
28 Supervision of gross motor			0.70		0.49
10 Health practices				0.69	0.54
9 Toileting/diapering				0.52	0.39
8 Meals/snacks				0.48	0.21
1 Indoor space				0.48	0.34
5 Child-related display					0.19
11 Safety practices					0.05
16 Becoming familiar with print					0.40
19 Art					0.08
20 Blocks					0.01
22 Nature/science					0.12
23 Math materials and activities					0.11
24 Math in daily events					0.15
25 Understanding written numbers					0.21
26 Promoting acceptance of diversity					0.20

Note: Factor loadings ≥ .40 are shown. Extraction method: Maximum Likelihood. Rotation: Promax. Communality represents the proportion of variance explained by the extracted factors.

The *Learning & Play Environment* factor comprised items related to the physical and pedagogical organization and reflects the extent to which pedagogical activities, space and materials support children's learning and play. The *Interaction & Order* factor included items addressing classroom management, routines, and staff-child communication, suggesting orderly environments are closely associated with high-quality interactions. The *Gross Motor* factor consisted exclusively of items related to gross motor

activities and mirrors findings from previous research (Early et al. 2018; Montes et al. 2018). The final factor, *Care & Hygiene*, encompassed items related to care routines, including health practices, toileting, meals or snacks, as well as indoor space. These items share a common emphasis on hygiene, and the inclusion of indoor space likely reflects the role of physical environments in supporting hygiene care practices.

To evaluate the fit of this factor solution relative to the original ECERS-3 structures, we conducted a preliminary CFA. The final four-factor model demonstrated acceptable fit, RMSEA = .07, 90% CI [.05, .09], CFI = .91, $\chi^2[246] = 326.52$, $p < .001$. The non-significant RMSEA test ($p = .077$) indicates that the hypothesis of close model fit could not be rejected. This provided an improvement against earlier models and accordingly, this four-factor model was retained for subsequent analyses.

Sensitivity analyses treating item scores as continuous variables and using maximum likelihood estimation yielded the same pattern of results. Specifically, the one-factor model continued to exhibit the poorest fit, whereas the EFA-derived model showed the best fit, further supporting its selection.

Associations between ECERS-3 factors and structural variables

Simple regression analyses were conducted to examine associations between each structural variable and (1) the four-factor ECERS-3 model derived from the EFA and (2) the ECERS-3 total mean score. The latter was included to aid interpretation, given its widespread use in prior research. Results are presented in Table 4.

No structural quality variables were significantly associated with the ECERS-3 total mean score. In contrast, several significant associations emerged at the factor level. Gross Motor quality was higher in preschools with smaller group sizes. Care & Hygiene quality was higher in larger preschool centers and in preschools with lower proportions of licensed teachers. No significant associations were observed for the Learning & Play Environment or Interactions & Order factors.

Exploratory analyses

To compare the present findings with those based on the original ECERS-3 subscales and to investigate potential nonlinear associations related to group size, we conducted

Table 4. Simple linear regressions analyses for factors and mean ECERS-3 score.

	Learning & Play Environment	Interactions & order	Gross motor	Care & hygiene	ECERS-3 mean score
Teacher Education	0.30 (1.12), .03	0.45 (1.49), .00	−1.09 (2.03), .00	**−3.61* (1.43), .09**	−0.20 (0.79), .00
Child-to-adult Ratio	0.12 (0.18), .01	0.07 (0.22), .00	−0.30 (0.31), .01	0.30 (0.22), .03	0.08 (0.12), .12
Group Size	−0.02 (0.04), .00	−0.03 (0.05), .01	**−0.13* (0.07), .05**	0.02 (0.05), .00	−0.02 (0.03), .03
Preschool Size	0.00 (0.00), .00	0.00 (0.00), .03	0.00 (0.01), .00	**0.01** (0.00), .09**	0.00 (0.00), .00

Note: * $p < .05$, ** $p < .001$. Values represent unstandardized regression coefficients (β) and R^2 values, with standard errors in parentheses. R^2 values indicate the proportion of variance explained by each model. Teacher Education = Proportion of staff that are licensed preschool teachers, Child-to-adult Ratio = Number of children per full-time employee, Group size = Average number of children per group, Preschool Size = Total number of children enrolled in preschool.

additional exploratory analyses. Regression analyses were performed using the six original ECERS-3 subscales as dependent variables and the structural quality variables as predictors. Full results are presented in Supplementary Table SI1.

Preschool size was positively associated with quality on the *Space and Furnishings* subscale ($\beta = 0.01$, $t(69) = 3.36$, $p = .001$). Higher levels of teacher education and higher child-to-adult ratios were significantly associated with higher scores on the *Personal Care Routines* subscale, ($\beta = 0.09$, $t(69) = 2.52$, $p = .014$; and $\beta = 0.43$, $t(69) = 2.17$, $p = .033$, respectively). These findings indicate that both a greater proportion of educated staff and a higher number of children per adult were associated with higher ratings on this subscale. No other associations reached statistical significance (p-values > .05).

To examine potential non-linear associations suggested by Bowne et al. (2017), who proposed threshold effects for group size (>15 children) and child-to-adult ratio (>7.5:1), we conducted additional analyses. No preschools in the sample exceeded a child-to-adult ratio of 7.5:1. Restricting the analysis to preschools with an average group size of 15 or fewer resulted in a sub-sample of 36 preschools.

Within this sub-sample, associations between group size and ECERS-3 quality ratings differed from those observed in the full sample (see Table 5). Smaller group sizes were significantly associated with higher quality in the Learning & Play Environment and the Care & Hygiene factors, as well as with higher ECERS-3 total mean score. The association between group size and the Gross Motor factor was no longer statistically significant. Additionally, larger preschool size and higher child-to-adult ratios remained significantly associated with the Care & Hygiene factor. No other associations reached statistical significance.

Discussion

Understanding the relationship between structural and process quality is important for improving ECEC and promoting child development and requires reliable measures of quality. This study explored the factor structure of the ECERS-3 and its associations with key structural quality indicators, including teacher education, child-to-adult ratio, group size, and preschool size in Swedish preschools.

Our results suggested psychometric limitations in the ECERS-3's original six-subscale model and caution against relying solely on a total mean score, which may obscure important associations. Instead, four distinct factors emerged: Learning & Play Environment, Interactions & Order, Gross Motor, and Care & Hygiene. Associations with structural indicators were evident but often subtle, appearing most clearly in smaller group settings. Notably, smaller groups were linked to higher quality in learning environment, gross motor environment and supervision, hygiene practices, and overall ECERS-3 scores.

These findings contribute to ongoing discussions on the validation of the ECERS-3 scales (see Alpys and Hernández-Torrano 2025, for a review) and to debates on the contextual and cultural adaptation of quality assessment instruments, particularly regarding variations in how ECERS-3 operates across national and pedagogical contexts (e.g. Garvis et al. 2018; Nasiopoulou et al. 2023).

Table 5. Simple linear regression analyses for factors and mean ECERS-3 score in centers with group size ≤ 15 (N = 36).

	Learning & Play Environment	Interactions & order	Gross motor	Care & hygiene	ECERS-3 mean score
Teacher Education	−1.52 (1.58), .03	−2.06 (1.83), .04	0.23 (2.76), .00	**−3.42* (1.59), .12**	−1.28 (1.00), .05
Child-to-adult Ratio	−0.23 (0.28), .02	−0.16 (0.32), .01	0.58 (0.47), .04	0.32 (0.29), .04	0.03 (0.18), .00
Group Size	**−0.19* (0.08), .14**	−0.08 (0.10), .02	0.01 (0.15), .00	**−0.25** (0.08), .22**	**−0.11* (0.05), .12**
Preschool Size	0.00 (0.01), .02	−0.00 (0.01), .01	−0.01 (0.01), .01	**0.01* (0.01), .15**	0.00 (0.00), .00

Note: * $p < .05$, ** $p < .01$. [a] $p = 0.05$. Values represent unstandardized regression coefficients (β) and R^2 values, with standard errors in parentheses. R^2 values indicate the proportion of variance explained by each model. Teacher Education = Proportion of staff that are licensed preschool teachers, Child-to-adult Ratio = Number of children per full-time employee, Group size = Average number of children per group, Preschool Size = Total number of children enrolled in preschool.

ECERS-3 factor structure

Our EFA revealed a factor structure that aligns conceptually with prior models (Early et al. 2018; Montes et al. 2018). We identified four factors: (1) Learning & Play Environment – related to pedagogical activities and the physical structure of the pedagogical environment; (2) Interactions & Order – reflecting staff-child interactions and the ability to maintain an orderly atmosphere; (3) Gross Motor – all items concerning gross motor equipment and activity; and (4), Care & Hygiene – care-related items, all containing indicators related to personal hygiene. However, several items failed to load substantially onto any factor, underscoring challenges in establishing a robust, comprehensive factor structure.

The Learning & Play Environment and Interactions & Order factors map conceptually onto factors identified in previous research with ECERS-3 and earlier versions of the scale (Early et al. 2018; Montes et al. 2018). They show particularly strong convergence with the factor structure reported by Early et al. (2018). Seven of the ten items comprising the Learning & Play Environment factor align with their *Learning Opportunities* factor, and all items included in our Interactions & Order factor correspond to their *Teacher Interaction* factor. Owing to their larger sample size, their study also provides a more robust point of comparison than that of Montes et al. (2018). These factors appear to distinguish between two key aspects of quality: (1) the pedagogical environment and experiences provided within a center, and (2) the quality of interpersonal interactions and the resulting social atmosphere. This suggests that, despite local contextual differences, broad universal aspects of quality may be identifiable across contexts.

A notable difference from both Montes et al. (2018) and Early et al. (2018) was that three mathematics-related items (see Table 1, items 23–25) did not load onto any factor, and that several other learning activities failed to load coherently. This pattern may partly reflect Sweden's thematic, play-based curriculum, which emphasizes child agency, exploration, and holistic learning rather than explicit instructions in discrete subject domains (Swedish National Agency for Education 2019). Within such a pedagogical context, mathematics-related practice and other learning activities may be embedded across activities rather than enacted in clearly delineated ways, potentially weakening associations among items intended to capture a common construct. Alternative explanations include variation in teachers' beliefs and self-efficacy regarding mathematics (e.g. Galeano et al. 2024), as well as differing interpretations of mathematics-related practice. In addition, the lack of coherent loadings may reflect measurement limitations, such as restricted variability or reduced item sensitivity in contexts where learning instruction is less explicit.

Our analyses also identified a Care & Hygiene factor, encompassing 'Toileting/diapering,' 'Health Practices,' 'Indoor Space,' and 'Meal/snacks.' While diverse at first glance, these items reflect situations of care routines and possibly the degree to which the environment can support care behaviors. These items also share an emphasis on hygiene, which seems specific to the local context. These items were absent from Montes et al.'s structure (2018) and are grouped differently in Early et al. (2018).

Overall, our findings suggest that reliance on the ECERS-3's six published subscales may obscure important associations and contribute to inconsistent results across studies. While the total score can serve for broad comparisons, our results discourage

using the six subscales in their current form. Future revisions of the ECERS should consider re-evaluating item composition and consider psychometric findings from diverse cultural contexts. Given that these issues have been consistently documented across studies (Early et al. 2018; Montes et al. 2018), they raise important concerns regarding the use of ECERS as a foundation for quality improvement systems and care should be taken when creating such systems to account for the psychometric issues with scale aggregation. It is important to note, however, that this critique pertains specifically to aggregated measures and does not extend to the individual items. Consequently, the use of ECERS items for research analyses or formative assessments, where items are examined individually, remains appropriate.

Associations between ECERS-3 and structural quality

The four-factor model revealed several significant associations between process quality and structural quality indicators. Care & Hygiene quality was higher in larger preschools and in settings with lower proportions of educated staff. The positive association with preschool size may reflect unmeasured confounders, such as newer facilities with better hygiene-supporting designs, reflecting a more recent trend in Sweden of constructing larger preschool facilities. The association between lower levels of licensed teachers and better hygiene practices may seem counterintuitive; however, it could reflect different staff priorities. Licensed teachers might primarily focus on structured educational activities, while other staff could prioritize routine care tasks, including hygiene. Although speculative, this finding suggests that greater emphasis on structured educational practices in settings with more licensed teachers may coincide with less attention to basic care routines, underscoring the need to balance educational and care-related aspects of quality.

Gross Motor quality was higher in smaller groups, likely because fewer children allow for more physical space for movement and easier supervision. This finding is important as gross motor activities and play in preschools benefit children's development of fundamental motor skills (Grady et al. 2025) and correlate positively with future academic achievement (Katagiri et al. 2021). However, this association ceased to be significant in groups of 15 or fewer children suggesting a threshold effect: reducing larger group sizes may enhance motor activity quality, but benefits plateau beyond a certain point.

Subsample analysis further supported the importance of smaller group sizes, associating them with higher quality in Learning & Play Environment, Care & Hygiene and overall ECERS-3 mean score. These results reinforce the argument that reducing group sizes to the suggested threshold or lower could serve as policy strategy for improving overall preschool quality. The non-linear nature of these associations may also explain inconsistencies in previous research. If structural factors influence process quality within certain thresholds, then varying sample compositions could result in mixed or contradictory outcomes.

Although the original ECERS-3 subscales exhibited poor fit, significant associations with structural variables were still observed. However, interpreting these associations remains challenging given the unreliable loading patterns of subscale items.

Overall, the observed associations between structural quality and ECERS-3 scores were generally weak, consistent with prior research indicating only modest links

between structural and process quality. This likely reflects both measurement limitations and the reality that structural characteristics alone cannot ensure high-quality interactions and learning environments. Instead, the enhancement of process quality likely depends on a wider set of factors that enable reflective practice and professional growth.

ECERS-3 scores

ECERS-3 ratings in our sample were relatively low, averaging 'minimal quality.' ECERS-3 scores outside the U.S. often tend to be comparatively lower (Vermeer et al. 2016), potentially due to differences in conceptions of quality and curricula. Nevertheless, the ECERS-3 scores were lower than in previous Swedish research (e.g. Nasiopoulou et al. 2023 reported a total mean score of 3.97). This is possibly due to system-wide strains in the aftermath of the COVID-19 pandemic, including staff shortages and high community illness rates coinciding with our data collection. As a result, the general long-term quality level may be underestimated. Careful interpretation is required when comparing ECERS-3 scores across studies, as differences in observer training, or biases may introduce variations (Early et al. 2007). However, examination of the item indicators (see Supplementary Information and Supplementary Table SI2) suggests measurement error is unlikely to fully explain the mean score as most indicators' thresholds were based on objective statements (e.g. 'The staff do not use books with the children during the observation'). Instead, these low scores indicate genuine quality concerns, particularly in areas involving learning activities, which may limit the positive effects of preschool, especially for children from disadvantaged backgrounds. Future research should explore if these results reflect temporary COVID-related effects or systemic issues.

Limitations

This study's limitations include a relatively small sample size. Although simulation studies suggest that acceptable factor recovery can occur with samples of this size (Mundfrom, Shaw, and Ke 2005), the modest sample warrants cautious interpretation and underscores the need for replication in larger samples.

Further, ECERS-3 observations and structural variables were assessed at single time points, which reduces their temporal reliability. In reality, child-to-adult ratios, group sizes and access to educated teachers fluctuate on a day-to-day or hour-to-hour basis. Test-retest reliability of the ECERS-3 has however been found to be strong (Hestenes et al. 2019) and structural data reflect the averages of the year the observations were conducted. We also note that ECERS-3 inherently reflects a specific view of preschool quality, and alternative instruments might yield differing insights.

Conclusion

Our study underscores the necessity of validating the ECERS-3 factor structure before investigating associations with other outcomes. Our four-factor model highlighted meaningful associations with structural quality, showing that smaller group sizes related to higher quality across multiple domains, including gross motor activities, Learning & Play Environment, and hygiene practices.

Meanwhile, items intended to assess specific domains, such as mathematics, did not load as expected – reflecting the need to account for local curricular frameworks when applying measures of preschool quality. Some ECERS-3 items may require contextual adaptation to capture the forms of quality emphasized in Swedish preschools. Apparent psychometric weaknesses may therefore reflect cultural differences rather than true measurement error.

While structural factors such as group size, preschool size, and teacher qualifications were associated with certain aspects of quality, these effects were often nuanced and threshold-dependent. The relatively low ECERS-3 ratings observed also suggest that resource-intensive systems are not immune to quality shortcomings. Taken together, the results point to the potential value of directing attention toward interventions that explicitly target process quality. Structural factors should not be overemphasized when trying to improve process quality as the link between the two is weak.

Future studies should further refine these findings by employing larger and more diverse samples to replicate the factor structure identified here and further explore the potential of a more universal structure of process quality. In relation to structural quality, they should also explore possible threshold effects and incorporate direct measures of child outcomes. Such efforts could enhance assessments, better informing policies to improve early childhood education quality.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT 4o and ChatGPT 5.2 in order to improve the readability and language of parts of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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