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Review

The relationship between the child–staff ratio and process quality in early childhood education institutions: A meta–analysis

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ABSTRACT

This meta–analysis studies the association between the child–staff ratio and the process quality (ERS, CLASS, CIS, ORCE, and EQOS) in center–based Early Childhood Education and Care (ECEC) institutions and identifies potential moderating factors. It synthesizes evidence from 49 publications from 14 countries with data from 18.049 ECEC classrooms. Results of the three–level random effects model provided a small significant negative correlation (Z = – 0.12, p<.001), indicating a negative relationship between an increase in the number of children per staff member on the process quality across publications. Additional moderator analyses showed that the correlation was higher for mixed–age classrooms and younger children and more relevant for global process quality indicators. Worse child-staff ratios correlated to a lesser degree with the interaction quality. Effect sizes also varied according to the type of staff included in the calculation of the child–staff ratio. These results underline that research evidence is rather heterogeneous and should not be interpreted without context. The authors discuss important implications for policy and pedagogical practice.

The association between the child–staff ratio and the process quality in Early Childhood Education and Care (ECEC) institutions is a well–researched topic (NICHD ECCRN, 2000). However, research evidence from the last decades is rather heterogeneous across contexts, age groups, and measurement instruments (Blau, 2000; Slot, 2018). While previous systematic reviews showed that lower child–staff ratios are not directly related to better child development (Dalgaard et al., 2022; Perlman et al., 2017), a prior meta–analysis across 10 studies on the global process quality, measured through the Environment Rating Scale (ERS), found a small, significant negative correlation with higher ratios, meaning more children per staff member (Vermeer et al., 2016). Evidence, including other measures of process quality, however, sometimes also shows negligible associations between child–staff ratios and process quality (e.g., Barros et al., 2016; Pianta et al., 2005). This lack of consistency in results across process quality indicators underscores the need for a more comprehensive and systematic synthesis of contemporary research evidence on this topic, including an analysis of potential moderating factors that may explain heterogeneity in findings.

This meta–analysis contributes to filling this research gap by integrating a larger set of publications (*N* = *49*) and examining key conceptual and methodological moderators. Meta–analyses can be particularly helpful for identifying potential moderating factors across studies and thereby improving educational practices. We investigated conceptual moderators related to children's age in the classroom and the type of staff included in the child–staff ratio. In addition, we examined methodological moderators regarding the measurement of the child–staff ratio and the assessment of process quality across publications, using different process quality indicators (ERS, EQOS, CLASS, CIS, ORCE).

Structural quality aspects in ECEC institutions, such as the child–staff ratio, are important predictors of process quality, meaning high–quality educational activities and interactions between ECEC professionals and children (Anders & Oppermann, 2024). Even though adequate child–staff ratios do not guarantee higher process quality, regulating them is necessary to provide children with a high–quality ECEC experience. Structural quality aspects can generally be adjusted more easily by official regulations compared to other quality dimensions. By ensuring adequate child–staff ratios, professionals have more time for regular and meaningful interactions with children, which in turn contributes to better identifying and preventing early signs of learning disabilities or

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special needs of the children (de Schipper et al., 2007; Pianta et al., 2009). They are therefore a crucial research topic in the context of quality management in ECEC institutions across countries and contexts.

1. Theory

1.1. Structure–process model of pedagogical quality

The ecosystemic model argues that child development is not an isolated process but rather an interactive process with the environment, and ECEC institutions are a crucial primary microsystem for children that foster their competencies (Bronfenbrenner & Morris, 2006). A prominent model describing the concept of pedagogical quality in ECEC research is the extended structure–process model of pedagogical quality (Anders & Oppermann, 2024), which is based on the original version of the structure–process model (e.g., Kluczniok & Roßbach, 2014; Pianta et al., 2005). This model assumes an interconnection between central quality dimensions and allows researchers to empirically assess pedagogical quality through a multidimensional approach. According to the logic of the model, structural quality aspects (e.g., child–staff ratio, qualifications, or classroom size) directly influence the quality and quantity of interaction processes with children, also referred to as process quality. The interplay between these dimensions in the model shapes the pedagogical quality of the whole institution. The extended model by Anders and Oppermann (2024) includes a more detailed description of the quantity and quality of interactions between ECEC professionals and children at the group level, as well as with individual children. It also includes interactions with parents and integrates the role of ECEC professionals for pedagogical quality more directly through the dimensions of leadership and the professional competencies of the staff (see Fig. 1).

Empirical evidence shows that the process quality in ECEC institutions can significantly influence child development (Ulferts et al., 2019; Von Suchodoletz et al., 2023), and it is therefore an important determinant of children's later life. The requirements for ECEC professionals to provide high–quality interactions have increased over time (Johnson et al., 2021). It can be argued that this is due to the growing importance of ECEC institutions not only for caring for children but also for educating and promoting their development. High–quality interactions between professionals and children depend on how much time and capacity staff have to engage with each individual child. ECEC professionals are supposed to meet the individual needs of every child, which emphasizes the role of high structural quality in ECEC institutions (Vandell et al., 2010) in order to achieve this. The child–staff ratio, group size, and staff qualifications are often referred to as the "iron triangle" of structural quality aspects (Hayes et al., 1990). Researchers have argued that these three quality aspects are the basis for high quality in ECEC institutions, meaning that if these aspects are of low quality, it is much harder to provide high quality in other quality dimensions as well. It is important to mention, however, that structural characteristics affect the likelihood of high–quality care but do not guarantee it (Cryer et al., 1999; Phillipsen et al., 1997). Also, the impact of structural quality aspects, such as the child–staff ratio, on process quality is not determined by just one indicator, and researchers increasingly emphasize the role of staff's professional competencies (Slot et al., 2015).

1.2. Assessment of child–staff ratios

Child–staff ratios can be defined in various ways (Mashburn et al., 2008) and are often referred to by different terms like teacher–child ratio, child–staff ratio, caregiver–child ratio, or adult–child ratio, not always with a clear definition of what this term implies. In this review, we consistently use the term child–staff ratio, as it is a rather broad term and can incorporate various definitions of this concept When calculating the child–staff ratio, some researchers include all adults in a classroom, regardless of their qualifications, professionalization, or occupation within the facility, while others consider only the number of ECEC professionals in the classrooms (Perlman et al., 2017; Viernickel & Fuchs–Rechlin, 2016). In addition, it is important to consider how much time ECEC professionals or caregivers realistically spend with children and how much time must be subtracted for vacation or sick days, administrative tasks, and professional development when calculating the child–staff ratio.

Therefore, it is necessary to make a distinction between two types of ratios. For the reported child–staff ratio, on the one hand, the full–time care equivalents of the children inside the classroom are divided by the number of full–time equivalents of all staff members (Viernickel & Fuchs–Rechlin, 2016). The observable child–staff ratio, on the other hand, considers only the immediate time ECEC professionals spend with children, excluding time spent on administrative tasks or when staff are absent (Viernickel & Fuchs–Rechlin, 2016). Typically, information on the reported child–staff ratio is collected through questionnaires, whereas the observable child–staff ratio is most commonly assessed through direct observations, ideally across multiple measurement

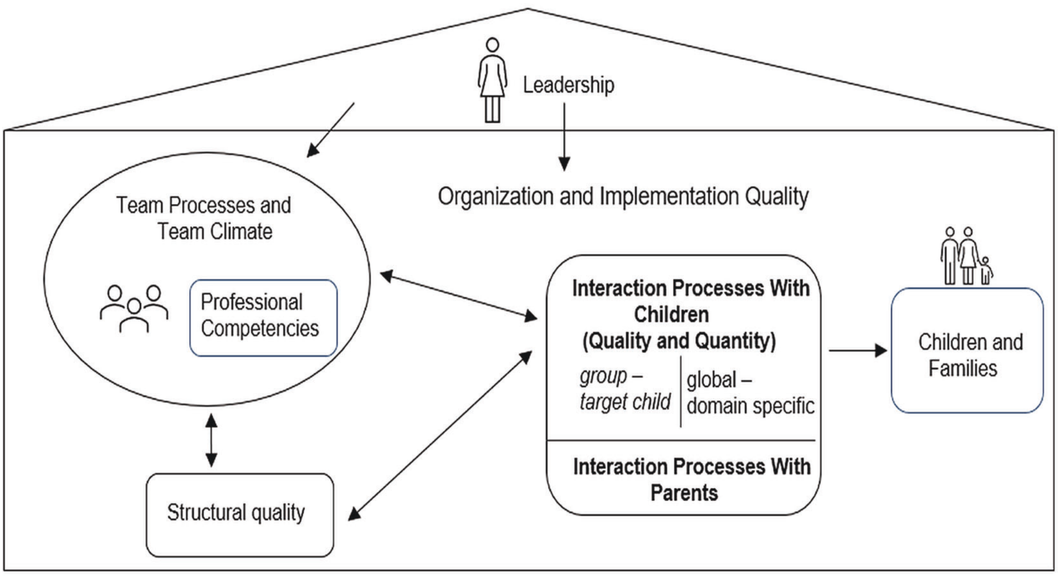

Fig. 1. Extended structure–process model (adapted from Anders & Oppermann, 2024).

points. Even though this distinction exists, many studies do not provide a clear definition of their operationalization when including the ratio in their analyses (Perlman et al., 2017), which, in turn, sometimes results in an unclear operationalization of the child–staff ratio across studies.

Previous studies show considerable variation in the real child–staff ratios across countries (see Ali et al., 2024; European Commission, 2019). Many countries regulate child–staff ratios through official guidelines or recommendations based on children's ages. These regulations, however, do not necessarily translate into age–appropriate ratios, and regulations are often not clear on whether the observable or reported child–staff ratio was assessed (Hausladen et al., 2026). Consequently, it is important to study the associations of both the reported and the directly observable child–staff ratio with the process quality.

1.3. Assessment of process quality

Process quality captures the experiences that take place in childcare settings, including children's interactions with ECEC professionals, peers, and participation in different activities (Vandell & Wolfe, 2000). Quantitative observational scales like the Environment Rating Scales (ERS) are prominent tools for assessing the process quality. The ERS include the Early Childhood Environment Rating Scale (ECERS/ECERS–R; Harms et al., 1998) for children from ages 2.5 to 5 and the Infant/Toddler Environment Rating Scale (ITERS/ITERS(–R); Harms et al., 1990) for children below the age of 2.5. These scales were developed in the United States and adapted to various countries. The full scales of the ERS measure the global process quality, like the overall quality of interactions between ECEC professionals and children, the material, and the spatial environment. It is important to note that the ERS also incorporate features of the physical environment and thus also assesses structural quality aspects such as the space of the facility. Therefore, there is criticism regarding their lack of focus on the substantial interactions inside the classrooms (Cassidy et al., 2005). Other observational scales assessing the process quality on a more general level, developed in Quebec, are the Educative Quality Observational Scales (EQOS; Bourgons & Lavallée, 2004a, 2004b).

Process quality instruments that focus on the observation of real child–staff interaction processes are the Classroom Assessment Scoring System scales (CLASS, CLASS–Infant, CLASS–Toddler; Pianta & La Paro, 2003). The CLASS is more commonly associated with the substantial staff–to–child interaction quality in the classroom and includes the dimensions classroom organization, emotional, and instructional support. The CLASS scales have been developed from the Observational Record of the Caregiving Environment (ORCE; NICHD ECCRN, 1996), which allows for comparisons between different types of childcare. Also, the Arnett Caregiver Interaction Scale (CIS; Arnett, 1989) focuses on four dimensions of specific educator behavior, namely the sensitivity, harshness, detachment, and permissiveness of the ECEC professionals inside the classroom.

In general, researchers differentiate aspects of the process quality into a global and domain–specific level. Whereas the global process quality encompasses the overall quality of interactions between ECEC professionals and children, the material, and the spatial environment, the domain–specific process quality focuses on particular aspects related to the acquisition of specific skills in competence domains, such as numeracy and literacy. An observational instrument developed to assess the domain–specific process quality is the Early Childhood Environment Rating Scale Extension (ECERS–E; Sylva et al., 2011). The ECERS–E includes aspects such as quality of stimulation and support in the domains literacy, mathematics, science and environment, and diversity practices. Although the aforementioned scales all capture aspects of the quality process quantitatively, important differences among them must be considered. The ERS include process as well as structural components and assesses the global process quality using a seven–point quantitative rating scale. While the CLASS and CIS also rely on rating scales, they capture the level and quality of interactions between children and ECEC professionals (Ulferts et al., 2019).

1.4. Review of previous studies on possible moderating factors between child–staff ratios and process quality

Researchers found that higher child–staff ratios, meaning more children per staff member, can increase the work burden for the staff, which in turn can lead to a lower quality of interactions, lower job satisfaction of the staff, or even safety problems (OECD, 2006; Pianta et al., 2009). When interpreting the research evidence on the association between the child–staff ratio and process quality, it is important to consider limitations on causal inference, as many studies are only correlational (de Schipper et al., 2006) and there is a predominance of cross–sectional designs. As previously argued, research evidence is heterogeneous across contexts, age groups, and measurement instruments (Slot, 2018). As a result, we provide an overview of research findings by age group, differentiating between the specific process quality indicators.

Regarding the age of children and the type of process quality, research findings from past decades suggest that the child–staff ratio is particularly important for the process quality in ECEC classrooms for younger children or infants (NICHD ECCRN, 2000; Phillips et al., 2000). Pessanha et al. (2016), for example, found small, significant associations for a lower teacher–infant interaction quality (CLASS–Infant and CIS) when child–staff ratios increased over time, but not for the ITERS–R. These findings indicate that classrooms with higher child–staff ratios reduce ECEC professionals' capacity to provide sensitive and responsive caregiving, especially in classrooms with high shares of infants who differ in developmental characteristics and needs. Further research with younger children demonstrated small to medium correlations between higher–quality interactions between ECEC professionals and infants, as measured by the ITERS–R, in classrooms with lower ratios (Barros & Aguiar, 2010; Barros et al., 2016; Deynoot–Schaub & Riksen–Walraven, 2005). Other studies found small to medium correlations for lower child–staff ratios and higher emotional support and teacher sensitivity, measured through the CLASS–Infant (Barros et al., 2016; Hulpia et al., 2016; Jamison et al., 2014; Pessanha et al., 2007; Thomason & La Paro, 2009). De Schipper et al. (2006) reported significant differences in an experimental study between classrooms with ratios of 3:1 and 5:1 in caregiver–child interactions, as measured by the CIS. Although these studies show a significant association in this age group, others do not support this. For example, other studies did not find a significant association between the child–staff ratios and the ITERS–R, CLASS, and CIS for infants and toddlers (e.g., Barros et al., 2016; Pessanha et al., 2007; Vogel et al., 2015).

Previous research evidence from older studies and reviews demonstrated the importance of adequate child–staff ratios for children ages three and above for the quality of caregiving and educational processes as measured through the ITERS/ECERS and CIS (Blau, 2000; Vandell & Wolfe, 2000). Some more recent studies mirror these medium associations for the process quality, measured through the EQOS, and some subscales of the ECERS–R and CLASS (Bigras et al., 2010; Dowsett et al., 2008; Gerber et al., 2007; Sandstrom, 2012). A study by Mashburn et al. (2008) in the US also found that the teacher–child ratio showed medium correlations with high emotional support (CLASS) from ECEC professionals and with the ECERS–R. Also, regarding the sensitivity or stimulation of ECEC professionals, some studies found a small positive association with a lower child–staff ratio, suggesting that a lower ratio was associated with higher domain–specific quality (Goelman et al., 2006; NICHD ECCRN, 2002). Although these studies show significant associations for this age group, evidence from other studies does not confirm this. For example, authors did not find a significant association between child–staff ratios and the ECERS–R, CIS, and CLASS (e.g., Goelman et al., 2006; Pianta et al., 2005; Slot et al., 2018).

In sum, associations for younger children and the ERS global process quality scales seem to be more consistent, and to a lesser degree, the

CLASS scales. Therefore, the age group and the type of process quality indicator seem to be important moderators concerning the association between the child–staff ratio and process quality. Many results, however, do not allow for causal links between these variables. Still, it is reasonable to assume that, especially in heterogeneous classrooms, including both children up to three years and older, ECEC professionals can face additional challenges due to the extra time they require, for example, for the preparation of activities. Studies show that a high age heterogeneity has been associated with a lower process quality (Early et al., 2010; Lehrl et al., 2014; Linberg & Burghardt, 2020). This underlines the staff's professional responsibility in the classroom. Research evidence indicates that a stronger staff professionalization may lead to smaller associations between the child–staff ratio and the process quality (e.g., Egert et al., 2021; Slot et al., 2015). It might therefore be important to consider which type of staff is included in the calculation of the child–staff ratio, as ECEC professionals may be able to compensate for the negative associations of higher child–staff ratios with process quality indicators (Slot et al., 2015). Consequently, the operationalization and assessment of the child–staff ratio may also be moderators of this association. Lastly, regarding the studies' context, results from a meta–analysis on the influence of country regulations on the relationship between child–staff ratios and process quality, for example, indicated lower correlations in mixed–age classrooms in countries with stricter regulations on the child–staff ratio (Hausladen et al., 2026).

1.5. Research aim

In this meta–analysis, our first goal was to aggregate contemporary empirical findings on the association between the child–staff ratio and the process quality in center–based ECEC institutions. Our second goal was to analyze potential moderators that might influence this relationship according to the current state of research, as evidence is rather heterogeneous and mostly based on correlational evidence. Process quality does not depend on just one single structural characteristic; rather, it is the consequence of a complex interplay of various factors (Slot et al., 2015; Viernickel & Fuchs–Rechlin, 2016), and additional variables are needed to explain the complete picture of quality (Blau, 2000; Whitebook et al., 2001). We therefore considered conceptual as well as methodological moderators for this association in our analyses. In sum, we aimed to analyze the following research questions:

1. How does the child–staff ratio relate to the level of process quality in center–based ECEC classrooms?
2. How does the association between the child–staff ratio and process quality in center–based ECEC classrooms differ according to conceptual as well as methodological moderators (age of children, type of staff included in child–staff ratio, measurement of the child–staff ratio, assessment of the process quality)?

Based on the research evidence, we expected to find a small negative correlation between the number of children per staff member and process quality (Vermeer et al., 2016). Regarding the moderators, we considered two conceptual moderators and argued that the association was stronger in classrooms with younger children and age–heterogeneous classrooms, compared to classrooms for children aged three and above. Furthermore, we assumed that only considering ECEC professionals in the calculation of the child–staff ratio would moderate the association (Egert et al., 2021; Slot et al., 2015).

We also investigated two methodological moderators. First, how the child–staff ratio was measured across studies (Perlman et al., 2017), distinguishing between studies that measured the directly observable ratio and those that calculated the child–staff ratio based on reports. We assumed that associations would be higher in studies that measured the observable child–staff ratio (Viernickel & Fuchs–Rechlin, 2016). As another methodological moderator, we investigated how authors assessed the process quality inside the classrooms across studies. Associations might have been weaker for interaction quality indicators, measured through the CLASS and CIS, compared to global process quality indicators like the ERS scales, which also capture structural components of the learning environment. Additionally, we explored differences in results for the domain–specific process quality.

2. Method

2.1. Study inclusion and exclusion criteria

To ensure the inclusion of comparable results, we predefined inclusion criteria that publications had to fulfill to be considered for further screening. We searched for studies published since the year 2000 to cover contemporary research on this topic. We only considered publications in English or German due to the language proficiency of the authors. Furthermore, we only included publications with data from center–based ECEC classrooms with children up to school enrollment. Publications on family daycare were excluded as these settings differ considerably from ECEC centers in their structure and assessment of process quality. We included cross–sectional publications and only considered evidence from publications with longitudinal research designs if they measured both the child–staff ratio and the process quality at the same time.

Concerning the predictor variable child–staff ratio, publications had to assess the real ratio between children and staff in the classroom. We excluded publications that reported the number of children in the classroom or the number of ECEC professionals in the classroom separately, as they did not provide coefficients on a directly calculated child–staff ratio. Regarding the outcome variable process quality, we incorporated only publications using well–established observational instruments (ITERS/ECERS(–R), ECERS–E, EQOS, CLASS, CIS, ORCE). We only considered observational instruments of the process quality as they capture the experiences and interactions of children in ECEC institutions more clearly in comparison to data from questionnaires (Garon–Carrier, 2019).

2.2. Systematic literature search

A first systematic literature search was carried out between October 2022 and March 2023 through relevant databases, including PSYNDEX, PsycINFO, ERIC (via EBSCOhost), and FIS Bildung for German publications. Table A.1 in Appendix A provides an overview of the keywords used in the databases. After we identified *2.796* publications through these databases, other sources like bibliographies of already identified articles and relevant review articles (e.g., Dalgaard et al., 2022; Perlman et al., 2017; Slot, 2018; Vermeer et al., 2016) were consulted to identify publications that we might have missed through the first screening process. We also carried out a manual search of publications by key authors and prominent studies in the field of ECEC research between November 2023 and January 2024, resulting in an additional *170* publications. First, we excluded duplicates and publications with irrelevant titles, and in the next step, screened the abstracts of the remaining *397* publications identified through databases and other methods combined. Then we read the full texts of the remaining *268* publications and excluded those that did not report relevant coefficients and those with missing information ($n = 33$). This resulted in a final sample of *49* publications that were included in the analyses. A PRISMA flowchart with a stepwise overview of the literature review and screening process is available in Fig. 2.

2.3. Coding scheme

The coding scheme included information on the child–staff ratio, the process quality, all relevant moderator variables, and the results of the statistical test of the association between the child–staff ratio and the process quality. In the initial coding, we coded 40 percent of the

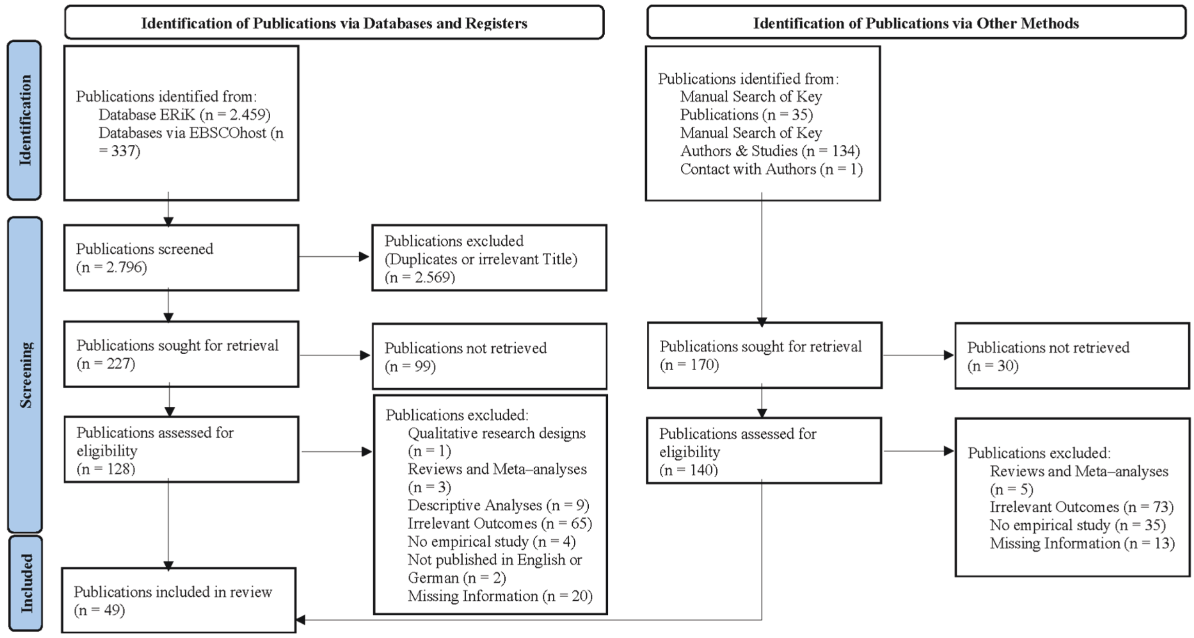

Fig. 2. PRISMA flowchart: identification and selection of publications.

publications twice to ensure the accuracy of the results. In case of discrepancies between coders, the results were compared and discussed until a common agreement was achieved. The final coding of the studies was double–checked.

In cases where publications lacked information necessary to calculate effect sizes or conduct moderator analyses, we contacted the authors and asked them to provide the missing data. We did not identify and therefore include any unpublished results. The publication bias that might arise from this is discussed further in the results section; however, an unsystematic inclusion of unpublished work might also lead to a distortion of the findings (Cook et al., 1993; Smith & Egger, 1998).

2.4. Moderator variables

In addition to performing a meta–analysis to identify the overall mean effect size for the association between the child–staff ratio and the process quality, we inspected potential conceptual as well as methodological moderators to explain sources of unexplained heterogeneity between effect sizes and publications. The relevant moderator variables were:

Age Groups: We categorized the observed classrooms from the publications into three groups depending on the age of the children (1) *classrooms with children below the age of three*, (2) *classrooms with children ages three and above*, and (3) *mixed–age classrooms* with children below and above the age of three. For publications reporting results across multiple age groups, we coded and analyzed them separately.

Type of Staff Included in the Child–Staff Ratio: We distinguished publications based on the type of staff they included in the calculation of the ratio. As publications differed in the terminology used to describe the child–staff ratio, when authors referred to "adults" or "staff" we coded these publications into the category (1) *all staff members*, if authors explicitly used the terms "educators", "caregivers" or "teachers" in their description of the variable in the method, we coded these publications into category (2) *only ECEC professionals*.

Measurement of the Child–Staff Ratio: We considered possible differences between publications that assessed the (1) *observable child–staff ratio* or the (2) *reported child–staff ratio*. When authors stated that the child–staff ratio was assessed via reports (mostly surveys) from staff or the director of the institution, this related to the reported child–staff ratio, and direct observations of the number of ECEC professionals and children present inside the classroom during the observation counted as the observable child–staff ratio.

Assessment of Process Quality: We categorized the previously mentioned process quality instruments into three subgroups (1) *indicators focusing on the global process quality*, (2) *indicators focusing on the interaction quality,* and (3) *indicators measuring the domain–specific process quality* (overview see Table 1).

2.5. Analytical approach

We used correlation coefficients as a basis to calculate effect sizes and applied Fisher's z transformation for the coefficients to be approximately normally distributed. This also stabilized the variance across effect sizes, so it would depend only on the sample size. Another advantage of Fisher's z transformation was that the approximate variance could be easily computed in practical applications and used for tests as well as for the construction of approximate confidence intervals (Schulze, 2004). If publications reported group differences rather than correlations between the ratio and the process quality (with corresponding statistics from t–tests, F–values, or Cohen's d), we converted these values into correlation coefficients before Fisher's z transformation. Some publications reported regression analyses instead of or in addition to bivariate correlations. For these publications, we examined the results in separate models and used the standardized regression coefficients and their standard errors directly as an effect size in the model.

Publications often included results from multiple analyses (e.g., results for the ECERS–R and the CLASS), meaning multiple individual

Table 1
Overview of categorized process quality instruments included in the analyses.

(1) Indicators focusing on global process quality	(2) Indicators focusing on interaction quality	(3) Indicators focusing on domain–specific process quality
ITERS(–R) ECERS(–R) EQOS	(in)CLASS (T)CIS ORCE Subscales of ERS-scales focusing on interactions	ECERS–E Subscales of instruments in categories 1 and 2 referring to the promotion of children in specific domains (e.g., language, socio–emotional)

effect sizes, and some publications used data from the same datasets in their analyses. Therefore, we had to account for this nested data structure due to the dependencies between effect sizes. We applied a three–level approach with individual effect sizes (e.g., multiple coefficients for different ERS subscales) at the first level, publications at the second level, and datasets at the third level. With this three–level model, we carried out the meta–analysis in R with the metafor package (Viechtbauer, 2010).

A random–effects model was applied to account for unexplained heterogeneity across publications. The random–effects model assumes that the average effect size in the population varies randomly, indicating heterogeneity (Hedges & Vevea, 1998). For each analysis, we reported the Q–statistic. Furthermore, we calculated the I^2–statistic (Higgins & Thompson, 2002) to assess the proportion of variance across the observed effect sizes in our sample. Using the I^2 in addition to the Q–statistic is helpful, as an I^2 above 50 percent indicates moderate heterogeneity even if the Q–statistic is not statistically significant. We weighted effect sizes across publications by the inverse variance so that effect sizes with greater precision would carry more weight in the analyses (Brannick et al., 2011; Marin–Martinez & Sanchez–Meca, 2010). To calculate effect sizes across all analyses, we used 95–percent confidence intervals and reported prediction intervals as an index of dispersion across effect sizes (Borenstein, 2019).

The moderator variables were entered as fixed effects and analyzed in separate models to avoid multicollinearity among conceptually related variables and to avoid loss of statistical power (Cooper, 2010). This allowed for a clearer interpretation of each moderator's unique contribution. By testing each moderator separately through a Q_M–test, we could investigate if they explained a significant proportion of residual heterogeneity in the true effect size (Viechtbauer, 2010).

2.6. Analysis of potential biases

To identify potential publication biases that might limit the results of this meta–analysis, we conducted sensitivity analyses using the metafor package. First, we inspected funnel plots for all models, utilized the trim–and–fill method to identify asymmetries, and performed a rank correlation test. Additionally, we carried out analyses for Cook's distance and a one–study remove analysis to examine the robustness and potential distortions in our sample (Viechtbauer & Cheung, 2010). We also performed subgroup analyses to test the robustness of our results, using a moderator analysis based on the sampling method of the publications, distinguishing between publications with random and non–random sampling methods.

3. Results

3.1. Description of publications included in the review

The analyses using Fisher's Z as an effect size included *139* individual effect sizes from 45 publications across *40* datasets. The analyses with standardized regression coefficients included *43* individual effect sizes from *15* publications with as many datasets. Due to the small sample size for the model with regression coefficients, we only report the overall effect size in the main text, and the remaining results are available in Appendix B. Regarding the geographical context of the publications, we were able to include data from *14* countries. An overview of relevant study characteristics per publication is available in Table C.1 (Appendix C). The overall sample included data from *18.049* ECEC classrooms, and most results referred to classrooms for children ages three and above ($n = 10.151$), followed by classrooms for children below the age of three ($n = 6.478$), and mixed–age classrooms ($n = 1.420$). The overall variation of the mean (*M*) child–staff ratio across publications and corresponding standard deviations (*SD*) was considerable across the sample. An overview of the *M* and *SD* of the ratio, based on *36* publications that reported these descriptive statistics, is available in bar chart E.1 in Appendix E. In classrooms for children under age three, the mean child–staff ratio ranged from *2.24* to *13.09* children per staff member. In classrooms for children ages three and above, the mean ranged from *4.20* to *18.23* children per staff member. The largest mean range was observed in publications assessing the child–staff ratio in mixed–age classrooms, ranging from *4.55* to *18.24* children per staff member.

Regarding the type of staff included in the child–staff ratio across publications, the majority considered only ECEC professionals when calculating the ratio ($n = 27$). In a smaller proportion of the sample, authors included all types of staff members in the calculation of the ratio ($n = 14$). The information was missing in eight publications due to the authors not reporting enough information or due to the information provided being too ambiguous, and we therefore excluded them from the moderator analysis. Concerning the measurement of the child–staff ratio across the sample, almost half of the publications ($n = 23$) measured the reported ratio through surveys, and almost as many publications ($n = 22$) measured the directly observable child–staff ratio in the classrooms. In four publications, the information on how the child–staff ratio was assessed was not available in the published article and was excluded from the moderator analysis.

In many publications, results on the association between the child–staff ratio and the process quality were reported for multiple process quality instruments. *35* publications included measures of global process quality (ERS $n = 32$; EQOS $n = 2$). Results for instruments focusing predominantly on the actual interactions between ECEC professionals and children (CLASS $n = 14$; inCLASS $n = 2$; CIS $n = 8$; TCIS $n = 2$; ORCE $n = 2$) were available in *31* publications. In addition, *10* publications also reported associations for the child–staff ratio on the domain–specific process quality (ECERS–E $n = 2$; subscales of other instruments $n = 8$).

3.2. Results of the overall model with Fisher's z

Most of the *139* individual Fisher's Z effect sizes were located between $Z = -0.8$ and $Z = 0.4$. A first look at the sample showed that most effect sizes were negative ($n = 77$), while the number of null effect sizes ($n = 44$) and positive effect sizes ($n = 18$) was much smaller. We applied the trim–and–fill method to the funnel plot (Fig. 3) for the individual effect sizes to identify potentially missing effect sizes and test for publication bias. This indicated some asymmetry on the right side of the funnel plot, pointing to missing positive effect sizes. The results of the rank correlation test, however, showed a very small negative correlation (*Kendall's tau* = –0.08, p = 0.191) between the effect sizes and the corresponding sampling variances, indicating that the risk of publication bias was rather low. A forest plot with an overview of the aggregated Fisher's Z effect sizes per publication is available in Figure D.1 (Appendix D).

We tested for heterogeneity between individual effect sizes through the Q–statistic. This indicated a significant between–study variance ($Q = 1064.15$, $df = 138$, $p < .0001$, $T^2 = 0.04$, $SE = 0.01$) which was confirmed by the significant Tau^2. The estimated I^2 for these effect sizes was 92% in total, with 15.78% within the effect sizes, 44.76% within the publication level, and 31.71% within the dataset level. This suggested a considerable proportion of the variance in the observed effect sizes in our sample, indicating a high percentage of systematic variance between the individual effect sizes and publications. These results validated the use of a random effects model to conduct the meta–analysis with Fisher's

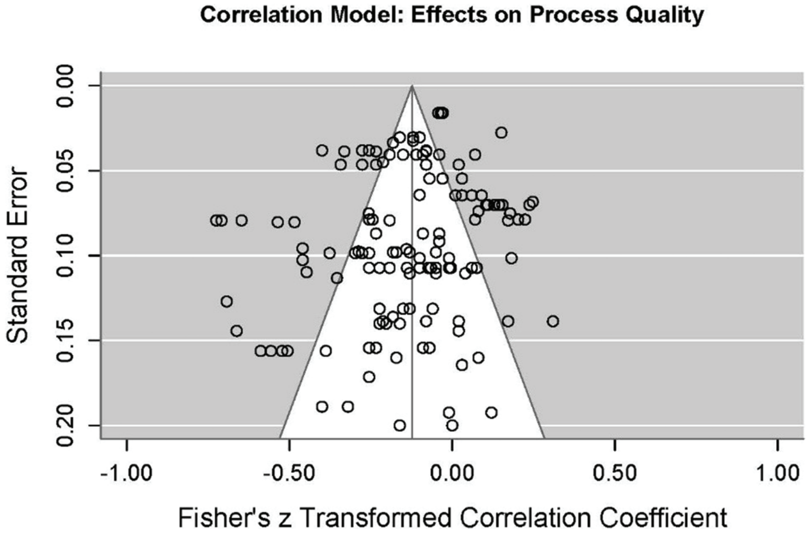

Fig. 3. Funnel plot with individual Fisher's z transformed correlation coefficients.

Z effect sizes.

For the overall model with Fisher's Z, we found a small, significant negative correlation for an increase in the child–staff ratio on the level of the process quality in the ECEC classroom (*Z = –0.12, 95% CI (–0.18, –0.06), p < .001*). This means that a higher number of children per staff member was associated with a lower process quality across the publications in our sample. The prediction interval showed that, in some publications, the negative correlation was expected to be as high as *Z = –0.46,* whereas on the other extreme, it was positive and as high as *Z = 0.26*[1].

3.3. Sensitivity analysis

We tested the model with Fisher's Z coefficients for differences in results between representative samples and non–representative samples to get a sense of the robustness of the effect sizes included in our analysis. This information was available in *32* publications from *30* studies. The test of covariance for the moderator was significant ($Q_M = 5.69, p < .01$). The results showed that the small mean correlation between the child–staff ratio and the process quality was somewhat smaller and not significant across the publications with non–representative samples *(Z = –0.12, 95% CI (–0.25, 0.02), p = .09*) compared to publications with representative samples (*Z = –0.13, 95% CI (–0.22, –0.04), p < .01*). The results of the one–study–remove analysis did not indicate that there might have been distortions in the results due to individual publications.

3.4. Results from moderator analyses

We performed moderator analyses with Fisher's Z effect sizes in line with our previously defined research question, due to the high level of heterogeneity in this model. First, we describe the results of the conceptual moderators, followed by the methodological moderators. All moderator variables were analyzed individually to assess the mean correlation within each predefined category and, therefore, judge the practical implications of these results.

3.5. Age of the children in the classroom

The moderator analyses on the age of the children in the classroom (Table 2) demonstrated important differences across the three subgroups, even though the Q_M–test did not indicate that this moderator explained a significant amount of heterogeneity across effect sizes. The mean effect size in mixed–age classrooms showed a medium correlation between the child–staff ratio and the process quality (*Z = –0.32, 95% CI (–0.47, –0.17), p < .001*), indicating that an increase in the child–staff ratio was negatively correlated with the level of the process quality. This effect size was also larger than in the overall model with Fisher's Z across all publications. In classrooms for children below the age of three, the average correlation was smaller (*Z = –0.14, 95% CI (–0.23, –0.05), p < .01*), but we still found a significant negative correlation. In classrooms with children ages three and above, we found an important difference compared to younger children and mixed–age classrooms, as the negative effect of the child–staff ratio on the process quality indicated a null effect for this subgroup while also not being significant (*Z = –0.06, 95% CI (–0.14, 0.01), p = 0.11*).

3.6. Type of the staff included in the child–staff ratio

Our second moderator, examining the influence of structural variables on the association between the child–staff ratio and process quality, was the type of staff included in the child–staff ratio across publications. Table 3 showed that the mean effect size for the subgroup with publications that included all staff members in the calculation of the child–staff ratio was a null effect size and not significant (*Z = –0.09, 95% CI (–0.20, 0.03), p = 0.13*). In comparison, the mean effect size for the subgroup of publications counting only ECEC professionals was similar to the small mean effect size in the whole sample (*Z = –0.13, 95% CI (–0.22, –0.05), p < .01*). The results of the Q_M–test showed that this moderator did not explain a considerable amount of heterogeneity across effect sizes.

3.7. Measurement of the child–staff ratio

Turning to the methodological moderators, we analyzed differences in effect sizes for the measurement of the child–staff ratio across publications and found that this moderator did not explain a significant amount of heterogeneity overall. We found a small, significant negative mean correlation for both the reported and the observable child–staff ratio (Table 4). However, in the case of publications that did not assess the child–staff ratio through direct observations, the significant small

[1] The results from the model with standardized regression coefficients showed a very small non-significant negative association across the *43* effect sizes (*ß = –0.06, 95% CI(–0.13, 0.01), p = 0.09).* Compared to the model with Fisher's Z on bivariate correlations, accounting for control variables in the model indicated a null effect size. This model, however, incorporated fewer coefficients from a smaller sample of publications, which prevented us from performing moderator analyses.

Table 2
Results of moderator analysis of the age group.

Moderator	Sample k	Test of covariance Q_M	Residual variance Q_E	df_E	Effect sizes of the Subgroups ES	SE	95% CI
Age of Children in the Classroom	139	0.01	1061.96***	137			
Classrooms for children below the age of three (n = 52)					–0.14**	0.04	–0.23, –0.05
Classrooms for children ages three and above (n = 70)					–0.06	0.04	–0.14, 0.02
Mixed–age classrooms (n = 17)					–0.32***	0.08	–0.47, –0.17

Note. Publications n = 45, Studies n = 40;.
*** <0.001,.
** <0.01, *<0.05.

Table 3
Results of moderator analysis for the type of staff included in the calculation of the child–staff ratio.

Moderator	Sample k	Test of covariance Q_M	Residual variance Q_E	df_E	Effect sizes of the Subgroups ES	SE	95% CI
Type of Staff Included in the Child–Staff Ratio	117	0.48	716.01***	115			
All Staff Members (n = 45)					–0.09	0.06	–0.20; 0.03
Only ECEC Professionals (n = 72)					–0.13**	0.04	–0.22; –0.05

Note. Publications n = 38, Studies n = 36;.
*** <0.001,.
** <0.01, *<0.05.

Table 4
Results of moderator analysis for the measurement of the child–staff ratio across publications.

Moderator	Sample k	Test of covariance Q_M	Residual variance Q_E	df_E	Effect sizes of the Subgroups ES	SE	95% CI
Measurement of Child–Staff Ratio	134	0.07	999.00***	131			
Reported child–staff ratio (n = 87)					–0.14***	0.04	–0.22; –0.06
Observable child–staff ratio (n = 46)					–0.12*	0.05	–0.22; –0.03

Note. Publications n = 43, Studies n = 39;.
*** <0.001, ** <0.01,.
* <0.05.

negative correlation was larger (*Z = –.14, 95% CI (–0.22, –0.06), p < .001*) than in publications measuring the observable child–staff ratio (*Z = –.12, 95% CI (–0.22, –0.03), p < .05*).

3.8. Assessment of process quality

As Table 5 shows, the moderator on the type of process quality indicator explained a considerable amount of heterogeneity ($Q_M = 8.68$, *p < .01*). We found a small to medium negative mean effect size in the subgroup with process quality indicators focusing on the global process quality (*Z = –.19, 95% CI (–0.26, –0.13), p < .001*). Turning to the mean effect size in the subgroup with indicators focusing on the interactions, the correlation provided a very small correlation (*Z = –0.08, 95% CI (–0.14, –0.02), p < .05*). Compared to this, the mean effect size of indicators assessing the domain–specific process quality was similar in size but not significant (*Z = –0.08, 95% CI (–0.18, 0.02), p = .11*). This showed, that for interaction–focused indicators, mainly measured through the CLASS and CIS, the negative effect of an increase in the child–staff ratio on the level of process quality was very small and not as substantial as for indicators assessing the global process quality in the classroom, like the ERS and EQOS. It also did not seem to be related to domain–specific quality indicators.

4. Discussion

4.1. Discussion of the overall effect size

In our meta–analysis, we systematically analyzed contemporary research evidence on the association between the child–staff ratio and process quality in ECEC institutions, drawing on a larger set of studies

Table 5
Results of moderator analysis of the assessment of process quality.

Moderator	Sample k	Test of covariance Q_M	Residual variance Q_E	df_E	Effect sizes of the Subgroups ES	SE	95% CI
Assessment of Process Quality	139	8.68**	963.28***	137			
Indicators Focusing on Global Process Quality (n = 54)					–0.19***	0.03	–0.26; –0.13
Indicators Focusing on Interactions (n = 72)					–0.08*	0.03	–0.15; –0.02
Indicators Focusing on Domain-Specific Process Quality (n = 13)					–0.08	0.05	–0.18; 0.02

Note. Publications n = 45, studies n = 40;.
*** <0.001,.
** <0.01,.
* <0.05.

than previous reviews. Due to the investigation of the role of conceptual and methodological moderators, this review provides novel insights into explaining heterogeneity across findings. Regarding our first research question, we found that the child–staff ratio was significantly related to process quality, with an overall small negative correlation ($Z = -0.12$). This suggests that an increase in the number of children per staff member in a given classroom was on average associated with a slight decrease in the observed level of process quality. These results support the evidence from the moderator analysis ($r = -.17$) across 10 studies in the meta–analysis on the ERS–scales by Vermeer et al. (2016). This negative correlation in our meta–analysis was, however, rather small, and the effect size from the model with regression coefficients, indicating a non–significant decrease of $\beta = -.06$ in the process quality when the number of children increased, suggests that other confounding variables may explain changes in this association. The effect sizes were also rather heterogeneous and should be interpreted in a context–specific manner and with regard to moderating factors.

4.2. Discussion of the results from the moderator analyses

Regarding the age of children in the classroom, our analyses indicated a small correlation for classrooms with children below the age of three ($Z = -0.14$), a medium correlation in mixed–age classrooms ($Z = -0.32$), and a null effect for classrooms with children aged three and above ($Z = -0.06$). The differences in the effect sizes support research evidence that the relationship can depend on the age of the children. A change in the ratio was more negatively correlated with a worse process quality in mixed–age classrooms and those including only younger children, similarly to the overall findings, but not in classrooms with only older children. Younger children need more immediate care from ECEC professionals, and therefore staff might struggle more to provide high–quality support to younger children if they have to meet the needs of more children at the same time (Pessanha et al., 2016; Phillipsen et al., 1997). This might be especially relevant in mixed–age classrooms, where children have different needs depending on their age. In classrooms with a high age heterogeneity, meaning both children below and above the age of three, ECEC professionals might face additional challenges to provide all children with the age–appropriate stimulation and interactions they require. The mean of the child–staff ratio in mixed–age classrooms was on average higher in the publications in our sample, meaning that particularly in these classrooms ECEC professionals had to care for more children on average (see Table C.1). A possible interpretation for the disappearance of the small to medium correlation in classrooms for older children could be that they are more independent and therefore do not need as much attention from the professionals compared to younger children (Early et al., 2010; Linberg & Burghardt, 2020). They might interact more with their peers instead and may need less guidance from the professionals. Thus, this evidence supports our initial hypothesis that a change in the number of children in these classrooms may not be consistently related to the level of process quality.

Regarding the type of staff included in the child–staff ratio, there was only a small negative correlation across publications with ECEC professionals included ($Z = -0.13$) rather than all staff members ($Z = -0.09$). This might indicate that a change in the child–staff ratio may have been less consistently related to the level of process quality when all staff members in the classroom were considered, regardless of their professional role. When interpreting the effect sizes with only ECEC professionals, it could be expected that fewer children per professional would improve the process quality to a higher degree than fewer children for all staff members in the classroom. Considering the professional role and responsibility of the staff in the classroom may therefore be important when interpreting results. This supports the discussion of the role of staff professionalization as a compensating factor between the association of higher child–staff ratios and process quality (Egert et al., 2021; Slot et al., 2015). Our moderator, however, did not assess the real professional competencies of the staff members, and our results do not allow for deductions about reporting guidelines on the role of these competencies for the assessment of child–staff ratios.

Our results for the moderator of the measurement of the child–staff ratio across publications demonstrated that the negative correlation was somewhat higher when authors measured the reported child–staff ratio ($Z = -0.14$) rather than the directly observable child–staff ratio ($Z = -0.12$). As differences were not large and both indicated a small correlation, they do not support our initial assumption that the association was higher when authors assessed the directly observable child–staff ratio. However, the assessment of the child–staff ratio varies considerably across publications, often lacking a clear definition of the operationalization of the ratio (Perlman et al., 2017). Our coding of both moderator variables on the assessment of the child–staff ratio only reflects the terminology and information provided by the authors in the publication. This does not necessarily relate to the factual distinction between the reported and the observable ratio, and it underlines the need for clearer reporting standards for this variable in future research. To improve comparability across results, authors should clearly report which types of staff are included in the calculation of the ratio, in relation to their professional role and responsibility in the classroom, and how the staff's presence was assessed (directly observed or reported). A guideline for clear reporting standards would be to implement a consistent term for the child–staff ratio, count only ECEC professionals, and use a direct observation method, ideally across multiple measurement circles (see Viernickel & Fuchs–Rechlin, 2016).

A change in the child–staff ratio seemed to matter more for the global process quality measured through indicators such as space, material, and provisions for learning, which the ERS and the EQOS focus on ($Z = -0.19$), indicating a small negative correlation. It did not seem to be as relevant for the meaningful interactions of the staff and (individual) children concerning the indicators of emotional and instructional support, as well as classroom organization (CLASS) or closeness and conflict interactions (CIS), showing a very small effect size ($Z = -0.08$). If staff members cared for a higher number of children, the quality of interactions with regard to these indicators did not seem to suffer as much, on average, compared to the global indicators, including aspects on a more quantitative level, like the use of material and activities. Indicators focusing on the direct support of ECEC professionals often assess the process quality for small groups of children or even individual children, meaning that even if the child–staff ratio in the overall classroom increased, the professionals may still have been able to offer high–quality interactions to these children.

Another explanation for these differences might be methodological. Observers using the CLASS to assess the interaction quality focus on one interaction in the classroom, disregarding other interaction processes happening at the same time. This might lead to a potential detection bias in the overall interaction quality in classrooms with higher ratios, as observers rate only interactions of similar quality. This underscores the need to differentiate between interaction quality at the group level and at the individual child level, as proposed by Anders and Oppermann (2024). A more nuanced observation of child–specific interactions (e.g., inCLASS) may capture the interaction quality with each child better than a group–level observation, in terms of the individual attention and support the child receives from the ECEC professional (Downer et al., 2010). Regarding the evidence for the global process quality, these results related mostly to the ERS scales. Some researchers criticize the ERS scales for combining structural and process quality aspects, claiming they do not directly capture the quality of interaction processes in the classroom (Cassidy et al., 2005). When interpreting the overall results, it is therefore important to distinguish which aspect of process quality the child–staff ratio matters and what the instruments substantially assess.

Taken together, only the moderator regarding the type of process quality significantly explained heterogeneity across effect sizes, indicating that small to medium correlations were mainly observed for global process quality indicators. There were also differences visible in the effect sizes for the conceptual moderators of the age of children in the classroom and the type of staff included in the child–staff ratio, even though these variables did not explain a significant amount of heterogeneity. Nevertheless, the age of the children seems to be important when interpreting results, as we only found small to medium correlations in mixed–age classrooms and for younger children, but not for classrooms with children ages three and above. Small correlations were also only visible when publications only included ECEC professionals in their calculations of the child–staff ratio, underlining the practical implications of differences across publications. Due to our moderator analyses being based on correlational evidence, other factors such as the staff's professional competencies or the type of curriculum may explain why higher child–staff ratios were not necessarily associated with a lower interaction quality and domain–specific process quality. Generally, the impact of a single structural quality indicator cannot explain the whole picture, as process quality is also determined by other factors (Slot et al., 2015), such as the social or language composition of the classroom, staff qualifications, and other aspects of staff professional competencies.

4.3. Limitations and future research

As a first limitation, the meta–analysis was not preregistered, which may be regarded as a limitation regarding the transparency of the research process. Another important limitation of our results was the missing data from publications necessary to calculate effect sizes. Authors sometimes did not report insignificant coefficients, so we could not use them in our analysis. Thus, our results might be restricted in the interpretation of the true population effect size. In addition, detailed information on the assessment of the child–staff ratio was often not available in the publications. We therefore discussed the coding information of the moderator variables in case of ambiguities in the publication.

A potential risk for publication bias was visible in the asymmetry of the funnel plot, but not confirmed through the rank correlation test. Assessing the asymmetry of a funnel plot can also be questioned whether it indicates a publication bias. Asymmetries could be due to other factors, such as systematic differences in publication sampling strategies or study designs, as well as small–study effects that can distort results (Borenstein, 2019). It is important to mention, however, that counterintuitive results, meaning an increase in the child–staff ratio leading to an increase in the process quality, are generally less likely to be published, and a publication bias can therefore not be ruled out completely.

Lastly, we could not account for cutoff values of the influence of the child–staff ratio on the process quality. Some research evidence suggests that the child–staff ratio might only impact the process quality if it is above a certain threshold (e.g., Pessanha et al., 2016). Our research evidence was primarily based on continuous variables, which did not allow us to investigate different levels of the child–staff ratio or how specific cutoff values would affect the process quality at those levels. Also, causal conclusions on higher child–staff ratios negatively affecting process quality indicators cannot be drawn from this correlational evidence. Thus, further research is needed to determine whether the negative effect sizes of the child–staff ratio persist when certain thresholds are taken into account.

4.4. Conclusions and recommendations for practice

In sum, this meta–analysis was the first to investigate moderating factors on the association between lower child–staff ratios (i.e., fewer children per staff member), including different process quality indicators. Lower child–staff ratios seem to be important for the global process quality but not the interaction quality in ECEC institutions. Even though previous systematic reviews showed that lower child–staff ratios were not directly related to better child outcomes (e.g., Perlman et al., 2017), structural quality aspects like the child–staff ratio can be regulated more easily compared to the process quality. The results from our moderator analysis suggest that child–staff regulations may be most efficient when they are tailored to the specific age composition and organizational structure of the ECEC classrooms. In particular, the stronger associations in mixed–age and infant/toddler classrooms underline that ratio regulations should prioritize groups with higher dependency needs and greater developmental heterogeneity among children. Moreover, given that global process quality indicators showed the most consistent associations with child–staff ratios, policy measures that strengthen structural conditions may have the greatest impact on broader aspects of the learning environment. At the same time, the weaker associations with interaction–focused indicators reinforce the need for structural reforms to be complemented by investments in professional development and interaction–focused training to meaningfully enhance the process quality.

CRediT authorship contribution statement

Kristina Hausladen: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Katrin Wolf:** Writing – review & editing, Validation. **Lars Burghardt:** Writing – review & editing. **Yvonne Anders:** Supervision.

Declaration of competing interest

We have no known conflict of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ecresq.2026.05.002.

Data availability

Data will be made available on request.

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