Is Cognitive Development at 3 Years of Age Associated with ECEC Quality in Norway?

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Abstract

In countries with universal access to early childhood education and care (ECEC), child participation is high across a range of socioeconomic groups. However, ECEC quality is often varying, and many children spend much time in ECEC settings that are not necessarily high quality. In this observational study, we therefore examined the relationship between observed ECEC quality and children's cognitive development at age three years in Norway–a country that provides universal access to ECEC from age one. The sample comprised 800 children, enrolled in 83 ECEC centers, who were assessed in verbal and non-verbal cognitive ability. ECEC quality was measured with the Infant/Toddler Environment Rating Scale (ITERS-R), and cognitive outcomes were measured with the Naming Vocabulary and Picture Similarities subtests of the British Ability Scales III (BAS III). The results showed that children's cognitive development at age three was not associated with ECEC quality; irrespective of socioeconomic background.

Keywords: early childhood education and care; cognitive development; ECEC quality; socioeconomic differences; GoBaN;

Because children’s cognitive developmental trajectories cannot be explained by heritability alone (Haworth et al., 2010), childhood experiences play an important role. In developed countries, many of these early-years experiences stem from early childhood education and care (ECEC) (OECD, 2015). The shift from parental care to institutional center-based care therefore gives rise to questions about how children are affected cognitively. Since cognitive abilities early in life predict future development and life chances (e.g., Knudsen, Heckman, Cameron, & Shonkoff, 2006; Shonkoff & Phillips, 2000), providing high quality care and stimulating ECEC environments has frequently been proposed as a way of reducing social disparities in children’s development (e.g., Burchinal, Zaslow, & Tarullo, 2016; Heckman, 2006; OECD, 2012). However, much of the current evidence on the effect of ECEC quality on children’s cognitive development comes from the U.S.–a sociopolitical context where children either attend targeted programs for disadvantaged children, or market-based programs chosen by parents. Yet, in many developed countries, ECEC is increasingly being used by a wide range of socioeconomic groups, exposing children with diverse backgrounds to ECEC settings that vary in quality. In this study, we therefore examine the relationship between ECEC quality and early cognitive development in a context of universal access to ECEC from age one (Norway). Furthermore, we examine whether disadvantaged children gain more from ECEC quality at all levels than their more advantaged peers.

Does ECEC Quality Predict Improved Cognitive Development?

In U.S. studies, the efficacy of high quality ECEC programs in improving disadvantaged children’s cognitive development has been shown to be relatively consistent across studies (see Camilli, Vargas, Ryan, & Barnett, 2010), albeit with more recent studies reporting somewhat lower effect sizes (see Duncan & Magnuson, 2013), and with effects sometimes diminishing over time (e.g., Barnett, 2011). Targeted programs that are specifically tailored to the needs of at-risk children and their families have generally proved relatively effective at compensating for inadequate home environments (as reviewed by Camilli, Vargas, Ryan, & Barnett, 2010)–at least in the short-term. These studies, however, have tended to measure the impact of high quality ECEC as contrasted with no center-based child care, rather than measuring the effectiveness of observed ECEC quality at different levels. Today, in many countries there is increasing ECEC availability–often at heavily subsidized prices–and ECEC is becoming a viable option for many families with children between 0-6 years, irrespective of family background. For these families, the question is not so much whether to use ECEC or not, but which ECEC center to use.

Previous studies examining relationship between variability in ECEC quality and cognitive outcomes have typically found relatively weak associations (Burchinal, Kainz, & Cai, 2011)–indicating that quality itself may be less important than simply attending ECEC at all (NICHD & Duncan, 2003). In contrast, a large-scale European study (EPPE / EPPSE) found substantial benefits of quality on long-term cognitive outcomes for high and medium quality ECEC, whereas low quality ECEC fared little better than home care (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2011). It has also been suggested that the magnitude of associations found in many studies may potentially have been underestimated due to model misspecifications, as proposed by Hatfield, Burchinal, Piantac, and Sideris (2016) who found indication that the relationship between observed quality and developmental outcomes may be non-linear rather than linear; linear being the most frequently modeled functional. Since Hatfield et al. found associations to be mostly evident in the upper part of the quality range, this could indicate that a minimum quality threshold level may be necessary for children to benefit substantially.

Does High Quality ECEC Reduce Social Discrepancies in Cognitive Outcomes?

The link between socioeconomic status (SES), a concept relating to a family's social and economic position, and children's development has been well-established, and studies have shown SES to be predictive of a variety of outcomes such as health, socioemotional development and cognitive development (Bradly & Corwyn, 2002; Hackman & Farah, 2009). The idea that a stimulating and enriched learning environment can promote development in children from disadvantaged (low SES) families has therefore been argued by many (e.g., Leseman & Slot, 2014; Magnuson & Shager, 2010; Sylva, Melhuish, Siraj-Blatchford, & Taggart, 2004)–a claim that has largely been substantiated by evidence from targeted programs and interventions (see Camilli et al., 2010; Duncan & Magnuson, 2013). However, the extent to which high quality ECEC is more strongly associated with cognitive outcomes for disadvantaged children as compared with more advantaged children is less clear. For instance, Dearing and McCartney (2009) found that the more children from low income families had attended above average quality care prior to school entry, the smaller was the difference in middle school achievement compared to their more affluent peers–regardless of these peers' experiences of quality of care. Several meta-analyses have however failed to find stronger effects for disadvantaged children (e.g., Burchinal et al., 2011; Keys et al., 2013). Despite the theoretical underpinnings of compensatory effects of higher quality ECEC on cognitive development for disadvantaged children (Ceci & Papierno, 2005), it is uncertain whether observed ECEC quality is, in fact, the critical ingredient.

Parental self-selection is a notable issue potentially affecting results in most studies assessing the effect of ECEC quality on cognitive outcomes (e.g., NICHD & Duncan, 2003). Parents make active choices when choosing which ECEC centers to use, and researchers mostly rely on controlling statistically for possible confounders (e.g., family income & education) to attempt to reduce the chances of selection bias from contaminating the results. Studies that have used experimental or quasi-experimental designs to counteract this potential source of bias, however, have found effect sizes mostly on par with previous meta-analyses (e.g., Auger, Farkas, & Burchinal, 2014). Nevertheless, it is unclear how self-selection manifests itself in a context of universal access, such as in Norway. Although parents have freedom of choice to select ECEC centers based on their own preferences, they may nonetheless be unable to discern high quality centers from low quality centers without adequate information, expertise or insight. Previous studies have shown some socio-demographic selection in timing of ECEC entry in Norway, with more advantaged parents tending to enroll their children earlier (e.g., Sibley, Dearing, Toppelberg, Mykletun, & Zachrisson, 2015; Zachrisson, Janson, & Nærde, 2013), but whether parents systematically differ in their ability to select ECEC centers based on objective quality criteria, depending on their socioeconomic background, is uncertain.

ECEC in Norway

Over the last few decades, Norway has expanded its ECEC sector considerably in order to provide universal access. Today, ECEC is heavily subsidized by the government, with a price-cap on family deductibles set to 2,703 NOK per month (equivalent to 305 Euros), with further reduced rates for low-income families (with a combined annual salary of less than 486,750 NOK–equivalent to 54 847 Euros) having to pay no more than 6% of their total income on full-time ECEC (ca. 7-9 hours per day). The most financially disadvantaged families (with a combined annual income of less than 417,000 NOK–equivalent to 46,988 Euros) are offered part-time ECEC (20 hours per week) for all children 3-5 years of age free of charge (The Norwegian Directorate for Education and Training, 2016b). ECEC is available from age one (for all children who have turned one-year-old within 1. September of the current year) (Norwegian Ministry of Education and Research, 2005). Uptakes are annual, and availability is guaranteed for all children with a statutory right; additional admissions are provided in accordance with local capacity, thus leaving the possibility for infants younger than 1 year old, or children without a statutory right to be admitted on regular terms. ECEC is also a widely popular welfare benefit, as the vast majority (> 90%) of children between 1 and 5 years attend either public or private ECEC centers in Norway. Most of them (> 80%) are enrolled as infants or toddlers (1-2 years), and attend full-time (Statistics Norway, 2016). Although some children are enrolled before the age of 1 year, these represent only 3.7% of the demographic (The Norwegian Directorate for Education and Training, 2016a).

Both private and public centers have equal status, are subject to the same governmental regulations, and receive equal financial support (Norwegian Ministry of Education and Research, 2016a). As such, private and public centers are unlikely to differ substantially in terms of quality. To ensure quality, all ECEC centers are required to implement guidelines from a national framework plan (Norwegian Ministry of Education and Research, 2011) into their curriculum, and conduct annual self-reports to their respective municipalities (local governments). The municipalities (and recently the County Governors) oversee all ECEC centers, and also conduct site inspections (Norwegian Ministry of Education and Research, 2005, 2016b)–albeit relatively infrequently (Gulbrandsen & Eliassen, 2013). However, it is worth noting the double role of municipalities as both supervisory authority and center owner. Given that municipalities run many of the centers which they are set to inspect, the expediency of such a quality control mechanism can be called into question–as conflicts of interest may occur.

The Present Study

In the present study, we investigated the relationship between ECEC quality and cognitive development at age three years in Norway. Because Norway provides universal access to ECEC, we were able to examine this relationship across a range of quality levels for different socioeconomic groups. We hypothesized that higher levels of quality are associated with higher cognitive performance at age 3, and that this association is moderated by socioeconomic background (i.e. parental income level and education).

Methods

Sample and Procedure

We used data from the first wave of Better Provision for Norway's Children in Early Childhood Education (BePro / GoBaN), a study of the use of ECEC and child outcomes in Norway. The study was approved by the Norwegian Center for Research Data (NSD) and the Norwegian Data Protection Authority. The sample consisted of 800 children (49.5% girls, age at cognitive assessment: M = 35.2 months, SD = 2.3 months) from 83 public and private ECEC centers located in proximity to major universities or university colleges, across 7 municipalities (Akershus, Nordland, Oslo, Rogaland, Telemark, Troms, Vestfold)–constituting a geographically diverse sample. Participants were selected through cluster randomization; a process in which ECEC centers are randomly drawn from a pool, and eligible attending children are subsequently recruited to the study. All parents with children born in 2011 or 2012, who attended a selected center, received an offer of participation–of which an estimated 60-70% accepted. Informed written consent was provided by parents on behalf of their children.

Data collection included an assessment session with the children, interviews with parents, and observations of quality within each unit (‘classroom’) in the ECEC centers. Prior to child assessments, fieldworkers spent time playing and getting to know the children by visiting their classrooms. Child assessment took place in a vacant room in the ECEC center, accompanied by a caregiver familiar to the child. The caregivers were instructed not to assist the children in solving the tasks, but to make sure the children felt relaxed and secure. Resource limitations necessitated that multiple children were assessed per visit, inducing some variance in children’s test age–ranging from 31 months to 43 months (M = 35.2, SD = 2.3). Children’s exact ages were recorded at assessment. Background information was collected through structured interviews with participants’ mothers, fathers or both–by trained research assistants in the ECEC centers during a weekday. Information on which parent was present during the interview was not recorded.

Measures

Cognitive outcomes. Cognitive ability was measured with two subtests from the British Ability Scales 3 (BAS 3) (Elliot & Smith, 2011) test battery, one verbal and one non-verbal. Verbal ability was measured with the ‘naming vocabulary’ subtest, where participants were shown a selection of picture cards, one at a time, and asked to name the depicted objects. Non-verbal cognitive ability was measured with the ‘picture similarities’ subtest, where participants were shown a series of picture cards and asked to place their respective cards on top of one out four possible alternative slots on a board. Only one slot shared a relationship with the participant's card, and the subtest measured the children's abilities to make logical inferences. The two tests were given in random order to avoid systematic bias related to limited concentration spans or mild fatigue over time. On both subtests, correct answers gave one point, while incorrect answers or no answer were scored as zero. Subsequently, raw scores were converted to standardized scores (called ability scores) in accordance with the scoring rules of BAS 3. These ability scores served as our two cognitive outcomes.

ECEC quality. Quality ratings were conducted observationally and measured with the Infant/Toddler Environment Rating Scale-Revised (ITERS-R) tool (Harms, Cryer, & Clifford, 2003). In its entirety, the scale comprises 39 items that are grouped into the following subscales: 1) Space and furnishings, 2) Personal care routines, 3) Listening and talking, 4) Activities, 5) Interaction, 6) Program structure, and 7) Parents and staff. The seven subscales are intended to represent different dimensions of quality for infants and toddlers in ECEC. The dimensionality of the instrument, however, has been contested, as factor analyses have indicated that ITERS-R better describes one global quality dimension instead of seven distinct dimensions (Bisceglia, Perlmana, Schaackb, & Jenkinsa, 2009). As a consequence, we collapsed the subscales into a total ECEC quality index by computing the mean of the individual items. The calculation was performed on a subset of the ITERS-R scale, consisting of the first 32 items from subscales 1-6, with items from the seventh (7. Parents and staff) omitted (information on subscale 7 was not collected by the BePro / GoBaN project, as it does not measure facilities for children). Possible values spanned from 1 (lowest quality) to 7 (highest quality). All raters received training from ITERS-R-certified researchers. Inter-rater reliability was high (≥ 80%), and ratings were conducted in accordance with Harms et al. (2003).

Socioeconomic background and covariates. Information about socioeconomic background factors and covariates came mostly from the parent interview. Income was defined as the gross annual income of the household and reported in Norwegian currency (NOK; 1 NOK = 0.11 Euro). Thirty-two families reported an annual income above the 95th percentile, while 38 families reported income levels below the 5th percentile–these were treated as outliers. Parents' educational levels were reported in the categories: 1) up to minimum compulsory education, 2) post-secondary vocational school, 3) post-secondary education, 4) bachelor's degree or lower university degree, 5) master's degree or higher university degree, and 6) other; the 'other' category (52 cases) was omitted from analysis because of its non-linear relationship with the preceding categories. From the provided information on maternal and paternal educational attainment, we created the composite measure 'highest attained education in the family'. Parents also provided information on weekly work hours, ethnicity (subsequently dichotomized as whether or not they were Norwegian), children's age at entry into ECEC, number of siblings, birth weight, and how often they read and played numbers games with their children. Center locations (municipalities) are referred to as 'sites' in the tables and listed in random order to preserve region anonymity.

Two additional variables were obtained through a combination of sources: gender was derived from the provided national identification number of the participating child, and children's age at cognitive assessment was calculated from birth date information and reported date of assessment.

Statistical Approach

Prior to conducting the statistical analyses, we made several adjustments to the data. First, we standardized the cognitive outcome variables to z-scores in order to ease interpretability and comparability of the estimated regression coefficients (*B*). As a result, the reported regression coefficients represent the predicted standard deviation difference in cognitive performance given a one unit increase in the independent variable of interest. Second, we limited the influence of outliers by winsorization–replacing extreme values with more probable values relative to the sample distribution (see Ghosh & Vogt, 2012). Values above the 95th percentile were therefore replaced with the 95th percentile, and similarly, values below the 5th percentile were replaced with the 5th percentile. Last, we dealt with the issue of missing data. Although most of the collected data were complete, information on income was a notable exception–with 12.5% missing values. To try to correct for this, we used regression imputation to estimate the most likely income levels for the missing cases based on other information provided, such as maternal and paternal education.

Following these data adjustments, we tested our research hypotheses by performing a series of ordinary least squares (OLS) multiple regression models. To account for the possibility of within-cluster correlated errors, resulting from children being grouped together in ECEC centers and thus producing too narrow confidence intervals (see Cameron & Miller, 2015), we reported cluster-robust standard errors–on center level. In total, we estimated four regression models. The first model (Table A1: model 1) tested the hypothesis that children's non-verbal ability at age 3 years varied as a function of center quality. The model was fitted by regressing non-verbal ability scores on ECEC center quality ratings (ITERS-R score), while controlling for family background factors; age at time of test; and other covariates (listed under Measures). Similarly, the second model (Table A1: model 2) tested the hypothesis that verbal cognitive ability at age 3 years varied as a function of ECEC center quality and was fitted by regressing verbal performance scores on ECEC quality rating and the aforementioned covariates. Thus, both models differed only in outcome measure, while containing the same set of independent variables.

Further, we assessed whether the association between ECEC quality and cognitive ability at age three was moderated by family income and education, by including two-way interaction terms ($ECEC\ quality\ \times\ income, \&\ ECEC\ quality\ \times highest\ educational\ attainment$) in the regression models (Table A1: model 3 & 4). These interactions were also inspected visually from Figure 1A-B and Fig. 2A-B, which show the estimated associations between ECEC quality and cognitive performance at age three (y-axis) across children from different family backgrounds pertaining to income level and educational attainment (x-axis).

Finally, we considered the potential influence of selection bias. Systematic differences in parental preferences for ECEC centers based on specific characteristics could result in some children gaining access to higher quality care than other children as a result of their family background. We therefore addressed this issue in our last model (Table A1: model 5) by regressing ECEC quality on variables that might be related to either parental choices, background or child characteristics. The model predictors included: family income; highest attained education in the family; parental ethnicity; number of children in the family; maternal work hours; reading frequency; child gender; child enrollment age; and child birth weight.

Results

A substantial proportion of the children in the study came from families with an annual income level close to the population median for families with 0-6 year-olds ($Median =$

$1{,}000{,}000\ NOK\ [gross] - equivalent\ to\ 111{,}039\ Euros,\ SD =\ 370{,}306\ NOK - equivalent\ to\ 41{,}118\ Euros$) (Statistics Norway, 2014). Yet, educational levels among parents were high, with a majority (84.2%) coming from families with at least one parent having attained university level education. Nearly all children (92.1%) attended ECEC full-time ($M = 7.3\ hours/day,\ min = 4\ hours,\ max = 9\ hours,\ SD = 0.85\ hours$) and were enrolled in centers of varying quality–ranging mostly between 'minimal' and 'good' ($M = 3.98$, $SD = 0.76, min = 1.65, max = 5.9$). During ECEC, the children were assessed on two cognitive outcomes–one verbal ($M = 93.8$, $SD = 20.87$), and one non-verbal ($M = 78.55$, $SD = 11.43$). Performance on these assessments indicated that the outcomes were only modestly correlated ($r = 0.33$, $p < 0.001$), reflecting the different aspects of cognitive development they are intended to measure. (A full list of descriptive statistics for all variables are displayed in Table 1).

Table 1. Descriptive statistics of all model variables.

Variables	N	Min	Max	Mean	SD
Cognitive Outcomes:					
Non-verbal ability score	798	25	133	78.52	11.48
Verbal ability score	789	10	140	93.83	21.09
Observed ECEC Quality Rating:					
ITERS-R score	800	1.65	5.9	3.98	0.76
Parent-reported SES Variables:					
Highest attained ed. in the family	787	0	5	3.18	0.93
Income (in 100K NOK)	795*	3.2	18	10	3.63
Mother's weekly work hrs.	800	0	55	30.99	13.27
Father's weekly work hrs.	800	0	75	36.45	11.93
Parent-reported Child Variables:					
Freq. letter play	800	0	5	1.80	1.54
Freq. numeral play	800	0	5	3.22	1.12

Freq. reading	800	0	5	2.9	0.79
Number of siblings	800	0	5	1.07	0.90
Days in ECEC pr. week	798	3	5	4.91	0.33
Hours in ECEC pr. day	798	4	9	7.30	0.85
Birth weight (in kg.)	800	1.25	4.9	3.5	0.54
Age at ECEC entry	800	6	36	14.78	3.86
Additional Covariates:					
Child's age at assessment	800	31.08	42.84	35.26	2.29
Child's gender (male = 1)	800	0.506	0.5	0	1

* = 12.5% of the cases in income were imputed.

Examining the relationship between ECEC quality and children's cognitive development at age three, we found that cognitive performance did not vary as a function of ECEC quality after adjusting for covariates in the regression models (Table A1: model 1 & 2). This was true for both cognitive outcomes, as ECEC quality did not predict either verbal performance ($B = -0.01$ $p = 0.814$) or non-verbal performance ($B = -0.022$, $p = 0.657$) at age three. The same pattern was found consistently between different socioeconomic subgroups, since the relationship between ECEC quality and cognitive development did not vary significantly across parental income (Figure 1A & Figure 2A) or education (Figure 1B & Figure 2B) distributions. Consequently, both the hypothesis that cognitive performance at age three was associated with ECEC center quality, and that this association was moderated by parental income and education, were therefore rejected.

To assess the possibility of the results being affected by selection bias, we also examined the relationship between family background factors, region and ECEC center quality ratings (Table A1: model 5). The results show that children with well-educated parents were more likely to attend higher quality ECEC than children from less educated families, even after controlling for region (site); a one unit increase in educational attainment in the family was associated with a

0.095 point increase in ECEC quality rating ($p < 0.01$). In contrast to parental education, family income did not predict ECEC quality ($B = -0.007, p = 0.42$). In general, there were few quality differences between regions, with only one region (site 6) being associated with significantly lower ECEC quality ($B_{site6} = -0.566,\ p < 0.01$) than the reference category.

Figure 1A-B. Effect of ECEC quality on non-verbal outcome across family income (A), and education (B) distributions

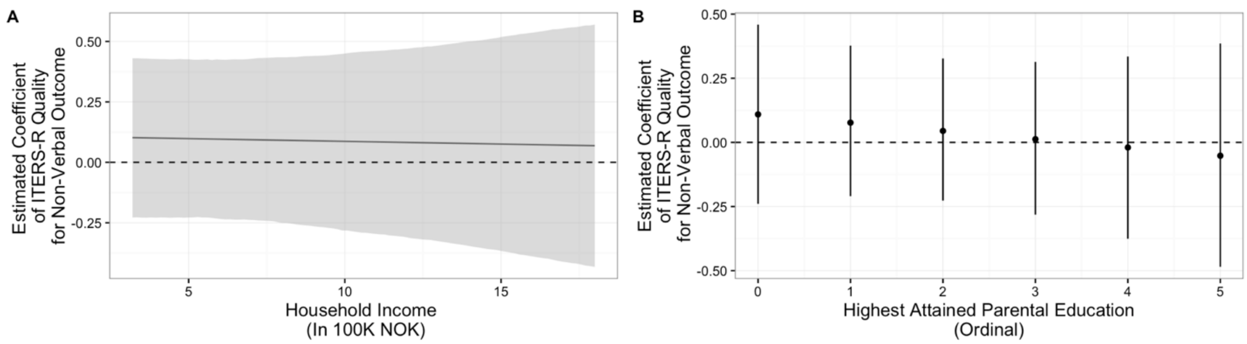

Figure 1. Plots depicting the estimated regression slopes of ECEC quality on children's non-verbal ability at age three years across different family income (A) and education (B) levels. Estimated regression coefficients are shown along the Y-axis, and family background variables along the x-axis. Household income has been scaled to 100K NOK (equivalent to 11 104 Euros). Highest attained parental education is categorical (see Socioeconomic background and covariates section*). Gray area in plot A, and vertical lines in plot B, represent the 95 confidence intervals. Dotted lines mark zero correlation.*

Figure 2A-B. Effect of ECEC quality on verbal outcome across family income (A), and education (B) distributions

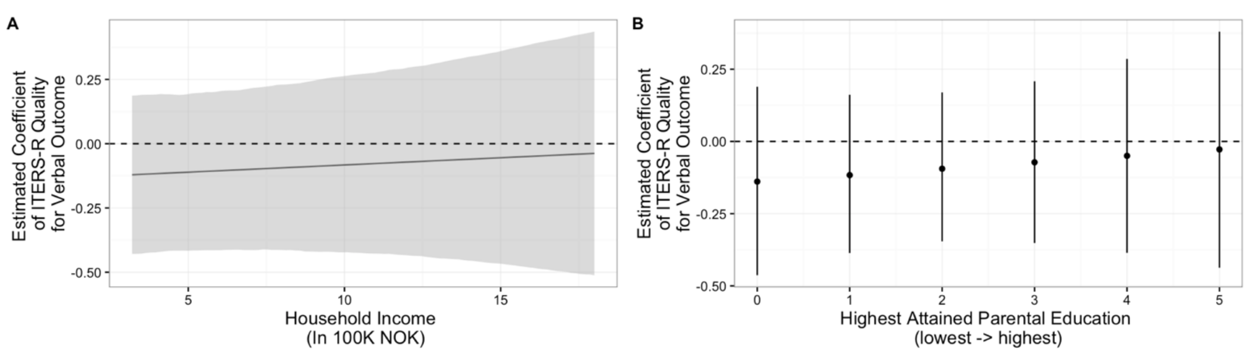

Figure 2. Plots depicting the estimated regression slopes of ECEC quality on children's verbal ability at age three years across different family income (A) and education (B) levels. Estimated regression coefficients are shown along the Y-axis, and family

background variables along the x-axis. Household income has been scaled to 100K NOK (equivalent to 11 104 Euros). Highest attained parental education is categorical (see Socioeconomic background and covariates section). Gray area in plot A, and vertical lines in plot B, represent 95%-confidence intervals. Dotted lines mark zero relationship.

Sensitivity analysis and robustness checks

In order to assess the robustness of the estimates, we re-specified the models in a number of ways. First, we conducted the analyses without data imputations (parental income had 12.5% imputed cases), which produced consistent estimates with models containing imputations. Second, we checked for domain-specific effects of ECEC quality by including ratings on all available ITERS-R subscales (1-6) (listed under Measures) as predictors in the regression models. As expected, due to the unidimensionality of the ITERS-R scale (see Bisceglia et al., 2009), neither subscale was more predictive than the aggregated total score used in the primary analyses.

Third, we replaced ‘highest attained education in the family’ with ‘maternal education’ in the interaction analyses on socioeconomic subgroups due to some indication that maternal education may be more important to children’s development than paternal education (Mercy & Carr Steelman, 1982). However, the choice was inconsequential to the results.

Fourth, we assessed whether the relationship between ECEC quality and cognitive ability was dose-dependent ($Quality \times Hours\ in\ ECEC\ per\ day$), but the effect of quality was absent regardless of how many hours the children spent in ECEC (in the range 4-9 hours).

Last, we took into account that there was some–albeit limited–indication of regional differences in level of ECEC quality provided for the children. As a final robustness check, we therefore tested whether the effect of quality on verbal and non-verbal ability differed depending on region ($Quality \times Sites$), but it did not.

Discussion

In this study of ECEC quality and cognitive development, we found no evidence that verbal or non-verbal abilities at age three are associated with ECEC quality. Nor did we find that socioeconomic background moderates the relationship, as there was no association between ECEC quality and the cognitive outcomes for either advantaged (high SES) or disadvantaged (low SES) children. Because previous studies in other countries have typically reported small but significant associations between ECEC quality and cognitive development (see Burchinal et al., 2011), the current null findings may reflect contextual differences between the present and previous research.

One explanation for the discrepancy may be that the children in this study were sufficiently stimulated at home, and that ECEC quality did little to further advance their development. Many of the parents were highly educated, middle class workers, with access to substantial welfare benefits–all of which are factors that may contribute positively to children's home-environments. As such, their children may have been particularly robust. However, 7% of the sample also consisted of children coming from disadvantaged (low income) families, which were hypothesized to be more strongly associated with effects of ECEC quality. This hypothesis was partly based on earlier studies indicating that most of the positive effect of attending Norwegian ECEC can be attributed to children of uneducated mothers (Havnes & Mogstad, 2011)–suggesting that disadvantaged children do not have equally stimulating home environments as their advantaged peers. The lack of association between ECEC quality and cognitive development across socioeconomic subgroups in the sample is therefore hard to explain.

Possibly, the range of ECEC quality in the study centers may have been too narrow, in the sense that the centers did not offer something substantially different from each other. As noted by Hatfield et al. (2016), much of the effect of ECEC quality may stem from exposure to the upper range of the quality spectrum, suggesting that the association between ECEC quality and cognitive outcomes may best be modeled non-linearly. However, we were unable to reproduce this in our study, as no signs of nonlinearities were present–although this may also be a reflection of the relatively modest number of high-quality centers in the sample.

Another explanation for why we could not find an effect of ECEC quality relates to the quality measure itself–ITERS-R. ITERS-R is primarily a measure of structural quality, and while structural quality may be easier to measure, process quality may be more likely to be predictive of cognitive outcomes. Furthermore, there has not been conducted any validation studies of the scale in Norway, where the pedagogical approach to early education is somewhat different from the context in which it originated. For example, free and uninterrupted play (i.e. low levels of adult engagement during free play), and high levels of child involvement are often considered to be hallmarks of Norwegian ECEC (Norwegian Ministry of Research and Education, 2013). Thus, it may very well be the case that aspects of the Norwegian ECEC pedagogy that potentially relates most strongly to cognitive development are not measured appropriately by ITERS-R. Consequently, although the participating children were exposed to a range of different ECEC settings according to ITERS-R, these ECEC settings may nevertheless not have differed substantially in ways that were important to the children's cognitive development.

The present study's failure to find an effect of ECEC quality emphasizes the difficulty of modeling complex relationships between cognitive development and ECEC settings based on observed quality measures. Nevertheless, it is our hope that the insights gained from this study may help steer future studies towards research designs that are increasingly able to further assess this important topic.

A notable limitation of the study is that it is based on observational (non-experimental) data. Although steps were taken to account for some plausible sources of bias, conditioning on covariates is unlikely to fully satisfy the ignorability assumption (Morgan & Winship, 2007). Furthermore, the data were also cross-sectional–leaving out the possibility of tracking cognitive abilities over time. Accordingly, children's cognitive development had to be deduced from their abilities at age 3 years. As such, in the absence of pre-test measures, developmental trajectories between time of ECEC entry and age three years could not be isolated. Obtaining such pre-test measures, however, would ultimately be infeasible, as most of the participating children were enrolled around infancy

Finally, it is worth considering the external validity (generalizability) of the study. Although educational levels in Norway are relatively high, the proportion of parents with university level education in the sample was twice the Norwegian average (Statistics Norway, 2015). This may in part be because sampling was restricted to centers located in close proximity to universities (mostly residing in urban areas), where educational levels are expectedly higher. However, it could also be an artefact of the parental recruitment process, given that highly educated parents may be more likely to accept the offer to participate in the study. Whatever the cause, generalizability to other populations may be limited.

Conclusion

In summary, we found ECEC quality–as measured by ITERS-R–not to be associated with children's cognitive development at age three years in a context of near universal access to ECEC. Furthermore, we found no evidence supporting the hypothesis that children from low SES backgrounds gain more from ECEC quality than their comparatively advantaged peers.

References

Auger, A., Farkas, G., & Burchinal, M. R. (2014). Preschool Center Care Quality Effects on Academic Achievement: An Instrumental Variables Analysis. *Developmental Psychology, 50*(12), 2559-2571. http://doi.org/10.1037/a0037995

Barnett, W. S. (2011). Effectiveness of Early Educational Intervention. *Science, 333*(6045), 975-978. http://doi.org/10.1126/science.1204534

Bisceglia, R., Perlmana, M., Schaackb, D., & Jenkinsa, J. (2009). Examining the psychometric properties of the Infant-Toddler Environment Rating Scale-Revised Edition in a high-stakes context. *Early Childhood Research Quarterly, 24*(2), 121-132. http://doi.org/10.1016/j.ecresq.2009.02.001

Bradly, R. H., & Corwyn, R. F. (2002). Socioeconomic Status and Child Development. *Annual Review of Psychology, 53*, 371-399. http://doi.org/10.1146/annurev.psych.53.100901.135233

Burchinal, M. R., Kainz, K., & Cai, Y. (2011). How well do our measures of quality predict child outcomes? A meta-analysis and coordinated analysis of data from large-scale studies of early childhood settings. *Quality measurement in early childhood settings, 11*.

Burchinal, M. R., Zaslow, M., & Tarullo, L. (2016). *Quality Thresholds, Features, and Dosage in Early Care and Education: Secondary Data Analyses of Child Outcomes* (Vol. 81). Wiley-Blackwell.

Cameron, A. C., & Miller, D. L. (2015). A Practitioner’s Guide to Cluster-Robust Inference. *Journal of Human Resources, 50*(2), 317-372. http://doi.org/10.3368/jhr.50.2.317

Camilli, G., Vargas, S., Ryan, S., & Barnett, W. S. (2010). Meta-Analysis of the Effects of Early Education Interventions on Cognitive and Social Development. *Teachers College Record*, *112*(3), 579-620.

Ceci, S. J., & Papierno, P. B. (2005). The Rhetoric and Reality of Gap Closing: When the "Have-Nots" Gain but the "Haves" Gain Even More. *American Psychologist*, *60*(2), 149-160. http://doi.org/10.1037/0003-066X.60.2.149

Dearing, E., & McCartney, K. (2009). Does Higher Quality Early Child Care Promote Low-Income Children's Math and Reading Achievement in Middle Childhood? *Child Development*, *80*(5), 1329-1349. http://doi.org/10.1111/j.1467-8624.2009.01336.x

Duncan, G. J., & Magnuson, K. (2013). Investing in Preschool Programs. *The Journal of Economic Perspectives*, *27*(2), 109-132. http://doi.org/10.1257/jep.27.2.109

Elliot, C. D., & Smith, P. (2011). *British Ability Scales–Third Edition (BAS-3)*: London: GL Assessment Limited.

Ghosh, D., & Vogt, A. (2012, 2012). *Outliers: An evaluation of methodologies.* Paper presented at the Joint Statistical Meetings, San Diego, CA.

Gulbrandsen, L., & Eliassen, E. (2013). Kvalitet i barnehager–rapport av strukturell kvalitet høsten 2012.

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65-73. http://doi.org/10.1016/j.tics.2008.11.003

Harms, T., Cryer, D., & Clifford, R. M. (2003). *Infant/Toddler Environment Rating Scale–Revised*: New York: Teachers College Press.

Hatfield, B. E., Burchinal, M. R., Piantac, R. C., & Sideris, J. (2016). Thresholds in the association between quality of teacher--child interactions and preschool children's school readiness skills. *Early Childhood Research Quarterly, 36*, 561-571. http://doi.org/10.1016/j.ecresq.2015.09.005

Havnes, T., & Mogstad, M. (2011). No Child Left Behind -- Subsidized Child Care and Children's Long-Run Outcomes. *American Economic Journal: Economic Policy, 3*(2), 97-129. http://doi.org/10.1257/pol.3.2.97

Haworth, C. M. A., Wright, M. J., Luciano, M., Martin, N. G., de Geus, E. J. C., van Beijsterveldt, C. E. M., . . . Plomin, R. (2010). The heritability of general cognitive ability increases linearly from childhood to young adulthood. *Molecular Psychiatry, 15*, 1112-1120. http://doi.org/10.1038/mp.2009.55

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*(5782), 1900-1902. http://doi.org/10.1126/science.1128898

Keys, T. D., Farkas, G. F., Burchinal, M. R., Duncan, G. J., Vandell, D. L., Li, W., . . . Howees, C. (2013). Preschool Center Quality and School Readiness: Quality Effects and Variation by Demographic and Child Characteristics. *Child Development, 84*(4), 1171-1190. http://doi.org/10.1111/cdev.12048

Knudsen, E. I., Heckman, J. J., Cameron, J. L., & Shonkoff, J. P. (2006). Economic, Neurobiological and Behavioral Perspectives on Building America's Future Workforce. *Proceedings of the National Academy of Sciences, 103*(27), 10155-10162. http://doi.org/10.1073/pnas.0600888103

Leseman, P. P., & Slot, P., L. (2014). Breaking the cycle of poverty: challenges for European early childhood education and care. *European Early Childhood Education Research Journal, 22*(3), 314-326. http://doi.org/10.1080/1350293X.2014.912894

Magnuson, K. A., & Shager, H. (2010). Early education: Progress and promise for children from low-income families. *Children and Youth Services Review, 32*(9), 1186-1198. http://doi.org/10.1016/j.childyouth.2010.03.006

Mercy, J. A., & Carr Steelman, L. (1982). Familial Influence on the Intellectual Attainment of Children. *American Sociological Review, 47*(4), 532-542.

Morgan, S. L., & Winship, C. (2007). *Counterfactuals and Causal Inference*. New York: Cambridge University Press.

NICHD, & Duncan, G. J. (2003). Modeling the Impacts of Child Care Quality on Children's Preschool Cognitive Development. *Child Development, 74*(5), 1454-1475. http://doi.org/10.1111/1467-8624.00617

Norwegian Ministry of Education and Research. (2005). Act no. 64 of June 2005 relating to Kindergartens (the Kindergarten Act).

Norwegian Ministry of Education and Research. (2011). Framework Plan for the Content and Tasks of Kindergartens.

Norwegian Ministry of Education and Research. (2016a). Finansiering av barnehager. Retrieved from https://www.regjeringen.no/no/tema/familie-og-barn/barnehager/innsikt/finansiering-av-barnehager/id2344788/

Norwegian Ministry of Education and Research. (2016b). Fylkesmannen kan føre tilsyn med barnehager.

Norwegian Ministry of Research and Education. (2013). Meld. St. 24 (2012–2013)–Framtidens barnehage. Retrieved from https://www.regjeringen.no/contentassets/2e8ad98938b74226bc7ff395839434be/no/pdfs/stm201220130024000dddpdfs.pdf

OECD. (2012). *Starting Strong III: A Quality Toolbox for Early Childhood Education and Care*. OECD Publishing.

OECD. (2015). PF3.2: Enrolment in childcare and pre-school.

Shonkoff, J. P., & Phillips, D. A. (2000). *From neurons to neighborhoods: The science of early childhood development*. National Academies Press.

Sibley, E., Dearing, E., Toppelberg, C. O., Mykletun, A., & Zachrisson, H. D. (2015). Do increased availability and reduced cost of early childhood care and education narrow social inequality gaps in utilization? Evidence from Norway. *International Journal of Child Care and Education Policy, 9*(1). http://doi.org/10.1007/s40723-014-0004-5

Statistics Norway. (2014). Inntekts- og formuesstatistikk for husholdninger, 2014. Retrieved from http://www.ssb.no/inntekt-og-forbruk/statistikker/ifhus/aar/2015-12-16

Statistics Norway. (2015). Befolkningens utdanningsnivå, 1. oktober 2015.

Statistics Norway. (2016). Barnehager, 2015, endelige tall. Retrieved from http://www.ssb.no/utdanning/statistikker/barnehager/aar-endelige/2016-04-20

Sylva, K., Melhuish, E., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2011). Pre-school quality and educational outcomes at age 11: Low quality has little benefit. *Journal of Early Childhood Research, 9*(2), 109–124. https://doi.org/10.1177/1476718X10387900

Sylva, K., Melhuish, E. C., Siraj-Blatchford, P. S. I., & Taggart, B. (2004). *The Effective Provision of Pre-School Education (EPPE) Project Technical Paper 12: The Final Report-Effective Pre-School Education*: Institute of Education, University of London/Department for Education and Skills.

The Norwegian Directorate for Education and Training. (2016a). Facts and analyses of kindergartens, primary and secondary education in Norway. Retrieved from http://utdanningsspeilet.udir.no/2016/wp-content/uploads/2016/10/Utdanningsspeilet_2016_en.pdf

The Norwegian Directorate for Education and Training. (2016b). Foreldrebetaling. Retrieved from https://www.udir.no/regelverk-og-tilsyn/barnehage/foreldrebetaling/

Zachrisson, H. D., Janson, H., & Nærde, A. (2013). Predicting early center care utilization in a context of universal access. *Early Childhood Research Quarterly*, *28*(1), 74-82. http://doi.org/10.1016/j.ecresq.2012.06.004

Appendix

Table A1. Regression table

	Dependent variable				
	Non-verbal ability	Verbal ability	Non-verbal ability	Verbal ability	ECEC Quality
	(1)	(2)	(3)	(4)	(5)
(Intercept)	-3.091** (0.884)	-3.436*** (0.884)	-3.590** (1.100)	-2.008. (1.149)	3.253*** (0.278)
Age at ECEC entry	0.002 (0.011)	-0.011 (0.009)	0.001 (0.012)	-0.014 (0.010)	0.023** (0.007)
Birth weight	0.016 (0.063)	0.077 (0.071)	0.014 (0.063)	0.084 (0.078)	0.082* (0.039)
Days in ECEC	-0.204* (0.085)	-0.046 (0.110)	-0.202* (0.085)	-0.090 (0.105)	-
Highest ed.	0.051 (0.045)	0.055 (0.041)	0.183 (0.201)	-0.039 (0.222)	0.095** (0.034)
Hours in ECEC	0.091* (0.045)	-0.043 (0.042)	0.091* (0.045)	-0.085. (0.046)	-
Income	0.014 (0.011)	0.016 (0.011)	0.021 (0.046)	0.019 (0.049)	-0.007 (0.009)
Quality	-0.022 (0.050)	-0.010 (0.044)	0.107 (0.144)	-0.099 (0.183)	-
Quality × Highest ed.	-	-	-0.034 (0.048)	0.020 (0.060)	-
Quality × Income	-	-	-0.002 (0.011)	0.000 (0.013)	-
Gender	-0.079 (0.069)	-0.147* (0.063)	-0.082 (0.069)	-0.141* (0.065)	0.001 (0.052)
Mother's work hours	0.000 (0.004)	0.004 (0.004)	0.001 (0.004)	0.007 (0.004)	0.002 (0.002)
Norwegian parents	0.080 (0.097)	0.627*** (0.087)	0.077 (0.097)	-	-0.071 (0.065)
Freq. numeral play	0.031 (0.035)	-0.029 (0.029)	0.031 (0.035)	-0.027 (0.031)	-0.006 (0.025)
Age at test	0.084*** (0.017)	0.090*** (0.017)	0.084*** (0.017)	0.088*** (0.018)	-
Freq. reading	0.014 (0.054)	0.050 (0.047)	0.015 (0.054)	0.036 (0.048)	-0.024 (0.031)
Number of siblings	-0.015 (0.036)	-0.029 (0.044)	-0.016 (0.036)	-0.037 (0.046)	0.003 (0.024)
Site 1	-0.110 (0.121)	-0.420** (0.124)	-0.115 (0.123)	-0.416** (0.135)	0.333. (0.199)
Site 2	0.314* (0.127)	0.136 (0.110)	0.312* (0.129)	0.073 (0.115)	-0.030 (0.240)
Site 3	-0.124 (0.127)	-0.304** (0.108)	-0.132 (0.130)	-0.357** (0.110)	0.186 (0.250)
Site 4	0.848*** (0.117)	0.213* (0.106)	0.847*** (0.119)	0.292** (0.098)	-0.121 (0.184)
Site 5	0.269 (0.163)	0.162 (0.146)	0.276. (0.163)	0.162 (0.122)	-0.424 (0.682)
Site 6	-0.154 (0.126)	-0.260* (0.103)	-0.152 (0.128)	-0.276** (0.097)	-0.566** (0.208)
Observations	780	780	780	780	780

Note: Cluster-robust standard errors in parentheses. Father's weekly work hours was omitted due to high correlation with mother's weekly work hours. ***p < 0.001; **p < 0.01; *p < 0.05; .p < 0.1