Cognitive Development and Social Competence in Early Childhood Education and Care

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Summary

Children's development is strongly influenced by early childhood experiences, particularly during sensitive periods such as infancy and toddlerhood. In Norway, over 80% of children aged 1-2 years are enrolled in ECEC, but despite being one of the few countries that have implemented universal ECEC from age 1 year, few studies have assessed the impact of infant/toddler enrollment on children's development.

In this dissertation, we assessed the importance of ECEC quality and children's age of entry into ECEC (timing of care) on children's short-term development at age 3 years. We used both non-experimental and quasi-experimental techniques to account for selection and omitted variable bias when estimating effects. In Paper I, we estimated the effect of ECEC quality on children's cognitive development using traditional regression analysis, adjusting for covariates. In Paper II, we estimated the causal effect of age of entry (for children who entered prior to age 2 years) on children's cognitive development, using instrumental variable analysis. We exploited a 'natural experiment' caused by national ECEC enrollment regulations using children's birth month as an instrument to partial out exogenous variation in age of entry. In Paper III, we estimated the causal effect of age of entry (for children who entered prior to age 2 years) on social competence – expanding on the approach from Paper II by embedding the instrumental variable design within a structural equation modeling framework which allowed for modeling social competence as a latent outcome.

The sample consisted of 700-800 children (born in 2011 & 2012) participating in the GoBaN study, who were recruited from over 80 randomly drawn ECEC centers located in 7 different urban areas in Norway. The majority of children came from relatively well-educated middle-class families and were assessed on cognitive abilities (verbal & non-verbal) and social competence. Cognition was measured using two assessments ('naming vocabulary' & 'picture similarities') from the British Ability Scales III, and social competence was measured using the Lamer Social Competence in Preschool scale.

Our findings showed that ECEC quality did not predict cognitive development at age 3 years – independent of socioeconomic background. In contrast, age of entry was an important causal influence for both cognition and social competence. Children performed on average an additional 14.1% of a standard deviation higher on non-verbal ability at age 3 years for every month earlier entry prior to age 2 years; there was no impact on verbal abilities. Surprisingly, children also performed on average an additional 32% of a standard deviation lower in social competence at age 3 years for every standard deviation earlier entry.

In conclusion, ECEC during the infant/toddler period exerts both a positive and negative influence on children's short-term development, resulting in a trade-off between cognition (non-verbal) and social competence for children enrolling prior to age 2 years. A policy-relevant implication of these findings is therefore that today's regulations which grant enrollment rights based on time of year of birth contribute to substantial heterogeneity in children's social and cognitive abilities in early childhood – with possible consequences for performance later in school. Although we found no relationship between ECEC quality and children's development, the use of Infant/Toddler Environment Rating Scale as a measure of quality in Norwegian ECEC has potential limitations and weaknesses.

Sammendrag

Barns utvikling er sterkt påvirket av tidlige barndomserfaringer, særlig de første leveårene. I Norge går over 80% av barn i alderen 1-2 år i barnehage, men til tross for at Norge er ett av få land som har full barnehagedekning fra ettårsalder, så har få studier undersøkt effekten av barnehage på de yngste barnas utvikling.

I denne avhandlingen studerer vi viktigheten av barnehagekvalitet og alder ved barnehagestart på barns kortsiktige utvikling ved 3-årsalder. Vi benyttet oss av både ikke-eksperimentelle og kvasi-eksperimentelle statistiske teknikker for å ta høyde for konfunderende faktorer (selection/omitted variable bias) i effektestimeringen. I første artikkel estimerte vi effekten av barnehagekvalitet på barns kognitive utvikling ved bruk av tradisjonell regresjonsanalyse, justert for kovariater. I andre artikkel estimerte vi den kausale effekten av barnehagestartalder (for barn som begynte i barnehage før fylte 2 år) på barns kognitive utvikling ved bruk av instrumentvariabelanalyse. Vi utnyttet et 'naturlig eksperiment' forårsaket av lovregulert rett til barnehageplass ved å bruke barnas fødselsmåned som instrument til å isolere eksogen variasjon i barnehagestartalder. I tredje artikkel estimerte vi den kausale effekten av barnehagestartalder (for barn som begynte i barnehage før fylte 2 år) på barns sosiale kompetanse. Med utgangspunkt i tilnærmingen fra andre artikkel implementere vi instrumentvariabel-designet i en strukturell modell (Structural Equation Model) som muliggjorde å analysere sosial kompetanse som en latent utfallsvariabel.

Utvalget bestod av 700-800 barn (født i 2011 & 2012) som deltok i GoBaN-prosjektet, og som ble rekruttert fra 80 tilfeldig valgte barnehager i 7 ulike urbane regioner i Norge. Flesteparten av barna kom fra høyt utdannede middelklassefamilier, og fikk kartlagt kognitive og sosiale ferdigheter. Kognitive ferdigheter ble målt ved bruk av British Ability Scales III, og sosial kompetanse ble målt ved bruk av the Lamer Social Competence in Preschool scale.

Resultatene viste at barnehagekvalitet ikke predikerte kognitiv utvikling ved 3-årsalder, uavhengig av sosioøkonomisk bakgrunn. Vi fant imidlertid at barnas alder ved barnehagestart var en viktig årsaksforklaring til variasjon i både kognitive (non-verbale) og sosiale ferdigheter. Barna scoret i gjennomsnitt 14.1% av et standardavvik høyere på non-verbale ferdigheter for hver måned tidligere de begynte i barnehage før fylte 2 år; verbale ferdigheter var upåvirket av barnehagestartalder. Noe overraskende scoret barna i gjennomsnitt også 32% av et standardavvik lavere på sosial kompetanse for hvert standardavvik lavere barnehagestartalder.

Konklusjonen er derfor at barnehage for de yngste både er positivt og negativt for barns utvikling på kort sikt dersom de starter i barnehage før de er 2 år; et kompromiss mellom kognisjon (non-verbal) og sosial kompetanse. En politisk relevant implikasjon av disse funnene er derfor at dagens lovregulerte rett til barnehageplass knyttet til når på året barna er født forårsaker vesentlig ulikhet i barns sosiale og kognitive ferdigheter i tidlig barndom, med mulige konsekvenser for seinere skoleresultater. Til tross for at vi ikke fant noen sammenheng mellom barnehagekvalitet og barns utvikling ved 3-årsalder, har bruken av Infant/Toddler Environment Rating Scale som kvalitetsmål på norske barnehager potensielle begrensninger og svakheter.

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Paper I

Eliassen, E., Zachrisson, H. D., & Melhuish, E. (2018). Is Cognitive Development at 3 Years of Age Associated with ECEC Quality in Norway? *European Early Childhood Education Research Journal, 26*(1). https://doi.org/10.1080/1350293X.2018.1412050

Paper II

Eliassen, E., Zachrisson, H. D., & Melhuish, E. The Causal Effect of Age of Entry into ECEC on Children's Cognitive Development. Submitted 2018.

Paper III

Eliassen, E., Zachrisson, H. D. The Causal Effect of Age of Entry into ECEC on Children's Social Competence. Submitted 2018.

1 Introduction

The likelihood of succeeding in school and later working life can to some degree be predicted from early childhood abilities and experiences (Currie & Almond, 2011). Providing for children in a way that is conducive to their development is therefore likely to improve their future chances. Outside the family, school is often considered the most important institution to promote children's development and early learning. But by the time children reach school-age, children's cognitive and social development is already well underway. Researchers and policymakers have therefore looked to early childhood education and care [ECEC] as a potentially important precursor to formal schooling by virtue of being an arena for children to develop socially and cognitively through play and interaction with others.

Not all children begin their formal schooling with equal chance of success, partly due to some children being readier for school than others (e.g., Schmitt, McClelland, Tominey, & Acock, 2015). Since the degree of school-readiness predicts later academic performance – irrespective of family background (Duncan et al., 2007) – the probability of succeeding in school is therefore conditional on previously developed abilities. Although some variation in children's abilities at school entry is attributable to genetics, genes alone do not account for children's early childhood developmental trajectories (see Davis, Haworth, & Plomin, 2009; Knudsen, 2004). Conditions relating to children's social environments therefore play an important part. For instance, children who play more with others adapt better to school-settings, most likely due to the acquisition of basic skills (Eggum-Wilkens et al., 2014).

Some variation in children's abilities is also explained by socioeconomic differences between families. Although likely to vary across countries depending on social conditions, studies on American children shed some light on the dynamics between socioeconomic status (i.e. family income and education) and academic achievement, showing that the gap between children of rich and poor families increases between generations; the importance of income inequality has almost reached that of parental education in the U.S. – largely driven by the strengthened relationship between above-median income families and their children's academic performance (Reardon, 2011). Although schools are intended to mitigate some of these differences by providing learning environments that reduce developmental disparities between children, they are largely unsuccessful in this role. Developmental gaps between children which are evident at school-entry tend to persist throughout the school years, and targeted interventions or reforms in elementary school or later do little to reduce these gaps (Heckman, 2006). Yet, where school interventions have proven ineffective in decreasing the achievement gap between advantaged and disadvantaged children, interventions prior to school have shown great promise (see Camilli, Vargas, Ryan, & Barnett, 2010; Heckman, 2006). If ECEC can indeed provide the necessary foundation for positive development then benefits are likely to also extend beyond pure academics, since children who feel competent, do well, and are satisfied with their schooling are also more likely to be happy later in life (see review by Suldo, Riley, & Shaffer, 2006).

In Norway, where there is universal access to ECEC, almost all children attend ECEC prior to formal schooling – typically enrolling during infancy or toddlerhood (Statistics Norway, 2017a). Such large-scale inclusion of infants and toddlers across the socioeconomic spectrum opens up questions of how children of these age groups and backgrounds are affected by attending full-time ECEC during such a sensitive period of their development (see Knudsen, 2004). However, the evidence on the effects of ECEC for infants and toddlers is relatively scant due to the comparatively low participation rates among these age groups in many other countries (see OECD, 2017). Furthermore, much of the research previously conducted has been targeted towards disadvantaged children, typically from sociopolitical contexts that differ substantially from those found in countries where ECEC is universally available from an early age. It is therefore unclear how infants and toddlers in universal ECEC are affected by their enrollment – especially when quality is varying (see Bjørnestad & Os, 2018). Yet, assumptions of the efficacy of ECEC is often made based on evidence from studies on disadvantaged children, without much support in empirical evidence (Baker, 2011). One reason for this may be that studies on disadvantaged children is more often experimental, whereas studies on broader populations enrolled in universal ECEC often lack the same rigorousness in research designs due to the inability to manipulate 'treatment' conditions – making it difficult to assert causal claims convincingly (see Morgan & Winship, 2007; Murnane & Willett, 2011).

As ECEC has grown increasingly popular among parents with infants and toddlers within many industrialized countries (OECD, 2017) – mostly due to increased governmental subsidies and expanded capacities – important questions remain about how children are affected by the shift from mostly parental-care to institutionalized care (ECEC). The aim of this dissertation is therefore to study how conditions in ECEC – specifically relating to age of entry and quality of care provided – during the first years of life affect their cognitive development and social competence at age 3 years, in a sample of Norwegian children. By identifying the determinants of child outcomes in ECEC, parents, policy-makers and practitioners will be better equipped to make informed decisions in how to provide all children with the best possible outlooks, as well as minimize the gap between children of different socioeconomic backgrounds.

The remainder of this dissertation is structured as follows: in the first part of the rest of the introduction I provide a brief theoretical overview of early childhood development in general and how ECEC has been found to relate to cognitive and social competence in previous research. In the second part of the introduction, I introduce some methodological and theoretical topics related to construct measurement, effect estimation, and the identification of causal 'treatment' effects in the absence of experimental data – all of which provide a framework for the approaches taken in Papers I-III. In the method section, I provide details on the sampling procedure, measures used, statistical techniques and choices made that build on key concepts presented in the introduction. In the results, I present the main findings from each of the three studies (Papers I-III) – one relating to the relationship between quality and cognitive development, and two relating to the causal effects of age of entry into ECEC (timing of care) on cognitive development and social competence, respectively. In the discussion section, I contextualize the findings and elaborate on some critical assumptions made and the feasibility of modeling the complex relationship between children's development and ECEC settings. Papers I-III are appended at the end.

1.1 Early childhood development

How children develop during the first years of life depends on many factors. For instance, having highly intelligent parents increases the odds of inheriting traits that result in above-average intelligence, as well as the likelihood of being exposed to environmental conditions that nurture one's full developmental potential. Since children's developmental trajectories cannot be accounted for by genes and inheritance alone, the remainder of the variation in abilities must therefore be explained by environmental influences (see Fox, Levitt, & Nelson III, 2010; Knudsen, 2004).

Infancy and toddlerhood are periods of high malleability and sensitivity (see Fox et al., 2010; Knudsen, 2004) during which many basic cognitive, social and emotional capacities are formed (Thompson & Goodvin, 2007) and developed at a rapid pace (Phillips & Shonkoff, 2000). Both genes and the environment (nature and nurture) – and the interplay between the two (epigenetics) (Bollati & Baccarelli, 2010) – affect these processes; together they determine children's growth and development. Twin studies have shown that genes explain 23% of children's general intelligence (commonly referred to as *g*) during early childhood (age 2-4 years), whereas shared-environment explains 74%. Interestingly, the importance of genes increases as children age, and by age 7-9 years genes account for 62% of cognitive ability, whereas shared environment accounts for only 33% (Davis et al., 2009). Genes also account for 50% of the variance in educational attainment across generations (Ayorech, Krapohl, Plomin, & Stumm, 2017). The environment children grow up in during the first years of life is therefore a strong explanatory factor for why some children develop more rapidly than others. The quality of children's home-environment has been found to account for more variance in educational attainment in primary school than typical socioeconomic predictors such as parental education (Melhuish et al., 2008). Socioeconomic factors relating to family resources (i.e. income level) are nevertheless important – but the negative force of growing up in poor families is lessened if parenting quality is high (Lugo-Gil & Tamis-LeMonda, 2008). One aspect of parenting quality relates to how sensitive parents are during interactions with their children. Children who have sensitive and responsive parents are more socially competent, though children become less susceptible to such parental influence as they age (Bradley, Corwyn, Burchinal, McAdoo, & Coll, 2001). Conversely, children who grow up in families with multiple risk factors (e.g., low family income, maternal depression, harsh parenting) during the first three years of life often have low school-readiness (Pratt, McClelland, Swanson, & Lipscomb, 2016). It is therefore clear that children are deeply influenced by their early life experiences (Knudsen, 2004; Shonkoff et al., 2012), but the degree to which they are sensitive or robust to various kinds of exposures or risk factors also depends on their personal characteristics (see Belsky & Pluess, 2013; Bradley & Corwyn, 2002).

1.2 From parental care to ECEC

The conditions under which children grow up have been changing rapidly over the last few decades for cohorts of children living in industrialized countries. Where children previously were primarily cared for by their parents, ECEC has today at least partially overtaken some of these care-providing responsibilities for many children. Thus, ECEC (child care) has evolved from a social welfare system for the few (mostly disadvantaged families), to a pedagogical and educational arena also functioning as an important precursor to formal schooling (see Cunha & Heckman, 2010; Elango, García, Heckman, & Hojman, 2015). In many countries, the transition from parental care to institutional care has happened rapidly, as parents have been enrolling their children into ECEC at increasing rates (OECD, 2017). Today, an average of 33% of all children under the age of 3 years attend ECEC throughout the OECD, and it is especially the youngest children who are more frequently being enrolled

(OECD, 2017). This development comes partly as a result of political reforms that have increased access to ECEC, making it more widely available and affordable for the general public. However, increased ECEC participation also coincides with – and is likely to have been influenced by – several societal trends such as rises in labor-market participation for women with young children; changes in family structures (more single-parent homes); and decreased fertility rates (less siblings in households) (OECD, 2017).

1.3 ECEC in Norway

Arguably, few countries have embraced the idea of universal access to ECEC as much as Norway. In just a few decades, the ECEC sector has been dramatically expanded. In the beginning of the 1980s, few parents (< 20%) enrolled their children (1-5 years) into publicly available ECEC, especially not infants and toddlers (< 10%). Today, nearly all children below school age (1-5 years) (91%) attend ECEC; the vast majority (82%) before the age of 3 years (see Fig. 1) (Statistics Norway, 2017a). Although there is no national registry of hours spent in ECEC, current findings indicate that over 90% of children attend full-time (7-9 hours per day) (Eliassen, Zachrisson, & Melhuish, 2018). Consequently, ECEC in Norway differs significantly from many countries due to the high attendance rates from a very young age. The relatively few who are not enrolled (or who postpone enrollment) are primarily children from disadvantaged and immigrant families (Sibley, Dearing, Toppelberg, Mykletun, & Zachrisson, 2015; Statistics Norway, 2017a; Zachrisson, Dearing, Lekhal, & Toppelberg, 2013; Zachrisson, Janson, & Nærde, 2013). Parents who wish to delay ECEC entry are offered a cash-for-care option for children under the age of 2 years (Norwegian Labour and Welfare Administration, 2017a), but few parents (< 25%) choose it (Egge-Hoveid, 2014).

To understand why so many Norwegian parents choose to enroll their children into ECEC, it is worth considering the following: employment rates in the general population are high (67.1% of 15-74 year olds, males = 69.3%, females 64.9%). Children are guaranteed the right to enroll from the age of 1 year (for all children who have turned 1 year within Sept. 1) (Norwegian Ministry of Education and Research, 2005) – only a few (3.7%) enroll earlier (Norwegian Directorate for Education and Training, 2016), mostly due to paid parental leave lasting up to a year or more after child birth (46 weeks at 100% pay, or 56 weeks at 80% pay) (Norwegian Labour and Welfare Administration, 2017b). Uptakes are coordinated within municipalities and apply to both publicly and privately run ECEC centers. Children that do not have a statutory right to ECEC enrollment are placed on waiting lists. Certain groups of children have priority, such as children with disabilities or special needs; children from disadvantaged families or children under protective care; children with siblings in the applied for ECEC center; and children of single parents (see Municipality, 2017). Private ECEC centers may also have additional uptake privileges in their statutes. Note that children are not prohibited from enrolling prior to having a legal entitlement, but that prior to obtaining such status there is no obligation for ECEC centers to accommodate them. Having access to ECEC is considered a public good, and public expenditure on ECEC is among the highest of any OECD country (Engel, Barnett, Anders, & Taguma, 2015). ECEC is both accessible and affordable due to the government subsidizing both public and private ECEC centers heavily and equally. Family deductibles are price-capped (max 2,703 NOK / 305 EUR per month); low-income families (< 486,750 NOK / 54,847 EUR annual household income) pay no more than 6% of their total income; and the most economically disadvantaged families (< 417,000 NOK / 46,988 EUR annual household income) are offered free part-time enrollment (20 hours per week) for children aged 3-5 years (Norwegian Directorate for Education and Training, 2016).

Furthermore, Norwegian ECEC is generally considered to be quite high quality. Centers are required to implement a national framework plan (Norwegian Directorate for Education and Training, 2017) into daily practice, which is designed to facilitate high quality. The national framework plan focuses on several aspects that are thought to promote cognitive and social competence development. For instance, the framework plan emphasizes that:

> [An ECEC center] shall create a stimulating environment that supports the children's desire to play, explore, learn and achieve. [ECEC centers] shall introduce new situations, topics, phenomena, materials and tools that promote meaningful interaction. The children's curiosity, creativity and thirst for knowledge shall be acknowledged, stimulated and form the basis for their learning processes. The children shall be able to explore, discover and understand correlations, broaden their perspectives and gain new insights

and:

> Social competence is key to interacting well with others, and it includes skills, knowledge and attitudes developed through social interaction. In [ECEC], all children shall feel that they are important members of the group and engage in positive interaction with children and adults. [ECEC centers] shall actively encourage the

children to develop friendships and social relationships. The children's self-esteem shall be supported, and they shall be given help to manage the balance between looking after their own needs and being considerate of the needs of others. (Norwegian Directorate for Education and Training, 2017, pp. 22-23).

Quality is also enforced through strict structural requirements such as staffing standards, and minimum teacher-child ratios. Centers are generally organized in several units ('classrooms') by age, typically with classrooms for 1-3 year olds, and classrooms for 3-5 year olds. For infant and toddler groups (1-3 years), centers must have at least 1 teacher per 9 children, whereas for older children (> 3 years) there must be at least 1 teacher per 18 children (Forskrift om pedagogisk bemanning, 2006). Teachers are also required to have a bachelor's degree in early childhood education or a 3-year equivalent (Barnehageloven [Kindergarten act], 2005), although assistants are generally untrained and comprise the majority of the care-providers (Gulbrandsen & Eliassen, 2013). Due to these factors, and the child-centric and play-oriented focus (high process quality) of Norwegian ECEC pedagogy, Norwegian ECEC is generally held to be of quite high quality. However, a recent empirical study found quality in Norwegian ECEC to be moderate and varying (Bjørnestad & Os, 2018).

Figure 1. ECEC attendance rates in Norway

National attendance rates of ECEC in the period 1980-2016, for children in the age groups 1-2 years (*dotted*), 1-5 years (*dashed*), and 3-5 years (*solid*). Data retrieved from Statistics Norway (2016).

1.4 ECEC and child development

1.4.1 Targeted ECEC programs (interventions)

The notion that ECEC can provide play and learning environments that are likely to promote children's cognitive and social development is not without merit – given the importance of exposing children to stimulating social contexts during the early years (see 'Early childhood development' section). Children need stimulating learning environments, typically lacking for disadvantaged children, which is why ECEC has often been proposed as a means to reduce social disparity by compensating for less-than-ideal home environments (e.g., Leseman & Slot, 2014; Magnuson & Shager, 2010). The efficacy of targeted ECEC has also largely been substantiated empirically, at least for disadvantaged preschool-aged (> 3 years) children receiving high quality care. In a meta-analysis of 120 American studies with experimental (and quasi-experimental) research designs spanning 5 decades, Camilli et al. (2010) found that targeted preschool programs for children of low-income families contributed substantially to later social competence and cognitive development. Similarly, in another meta-analysis of 84 experimental and quasi-experimental studies comparing Head Start preschool programs with other preschool programs, Duncan and Magnuson (2013) found an average effect size across studies to be between 25% and 35% of a standard deviation – depending on how scores were weighted. The overall picture is therefore that targeted ECEC generally yields positive and substantial effects. However, there is also heterogeneity in effect sizes depending on when the research programs were operative. Older studies often find larger effects, whereas more recent studies often find small or moderate effects. While there may be several explanations for this phenomenon, perhaps the most likely explanation relates to changes in counterfactuals between studies of different periods (see 'The counterfactual causal framework' section), since disadvantaged children are more likely to attend some form of center-based care today than in the 1970s.

Given the strong experimental research designs, intervention studies provide solid evidence that some children benefit substantially from receiving high quality provision during a developmentally sensitive period of their lives. But inference is also limited to narrow sub-demographics such as American children from low-income families – even though these have had ethnically diverse backgrounds. Despite most of the evidence of the efficacy of ECEC coming from American programs – which comprises the largest portion of the literature – comparable findings have also been found outside the U.S. (see Nores & Barnett, 2010).

The functional mechanism of these programs involves both directly improving children's cognitive development through early language stimulation (see review by Zauche, Thul, Mahoney, & Stapel-Wax, 2016) – and indirectly by enhancing executive functions (cognitive control) like inhibitory control, working memory, cognitive flexibility, which are important capacities for later schooling and academic performance (Diamond, Barnett, Thomas, & Munro, 2007). It is however important to note that estimating program effects from intervention studies on disadvantaged children often involves contrasts with children who did not attend ECEC (control groups) or children who ended up enrolling in lower-quality centers. These studies therefore more often answer the question of whether ECEC can mitigate negative outcomes that would have been probable had children not attended ECEC at all (the counterfactual condition) – but less often provides indication of how children in general with diverse backgrounds, and of younger ages, may benefit from ECEC at other quality levels – such as under a universal ECEC system. Furthermore, it is also often unclear which factors are driving the effects. Was it the teachers' sensitivity and responsiveness in child-interactions, or children's peer-play and early socialization that made the difference? Or perhaps the contrast between less-than-ideal home-settings with something more developmentally friendly? Most likely it was a combination of factors, all of which together resulted in the positive developmental outcomes that would not have been obtained under the alternative.

1.4.2 Quality

Outside intervention programs, the effects of ECEC are often estimated by assessing the relationship between child outcomes and measures of ECEC quality. But what is quality? A simple definition of quality could be whatever promotes a preferred outcome. From this definition, it follows that any determinant relating to ECEC could constitute high or low quality depending on whether it makes a positive or negative impact on the children. This allows for a wide range of quality factors – often categorized as either process or structural quality. Process quality relates to daily experience factors that directly influence children's experiences when in ECEC (e.g., teacher sensitivity), while structural quality relates to relatively stable factors that facilitate process quality (e.g., staff-child ratio, group size). Although process factors are generally considered to be the most important, structural factors are easier to measure and regulate (e.g., teacher/child-ratios, class size, center standards) (Litjens & Taguma, 2010). Quality in ECEC is typically measured using standardized observation tools (e.g., ITERS-R, ECERS-R, CLASS, ORCE), some of which attempt to capture both structural and process dimensions of quality. However, structural components are often better represented since process quality is both harder to measure and conceptualize.

The advantage of studying the effects of ECEC from observed quality is that the relationship between ECEC quality and child outcomes can be assessed at various levels – not just at high quality. However, findings from studies linking observed measures of quality with child outcomes have yielded somewhat mixed results. For instance, results from the large-scale NICHD Study of Early Child Care and Youth Development (SECCYD) showed that high quality (observed) predicted cognitive development consistently at age 24, 36 and 54 months, and social competence at age 24 and 54 months (NICHD Early Child Care Research Network, 2006; NICHD Early Child Care Research Network & Duncan, 2003). Similarly, high quality care was found to be correlated with higher social competence in a recent Dutch study on children aged 2-3 years (Broekhuizen, Aken, Dubas, & Leseman, 2017). For the youngest children, a nationally representative American study tracking children from age 9 months found ECEC quality during toddlerhood to be positively correlated with their cognitive development at age 24 months (Ruzek, Burchinal, Farkas, & Duncan, 2014). They did not find effects to be moderated by family background (high/low income) but found that children from low income families were disproportionately represented in lower quality care than children from higher income families. In most cases, however, effect sizes have tended to be relatively small. In a meta-analysis of 20 studies, frequently used measures of quality were found to be weakly to moderately linked to cognitive and social competence (Burchinal, Kainz, & Cai, 2011). These results have to some degree found support in a quasi-experimental study utilizing random assignment to different quality centers finding effect sizes mostly of the same magnitude (Auger, Farkas, Burchinal, Duncan, & Vandell, 2014).

Overall, low quality appears to have little benefit (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2011) and may even reduce the benefits of having a high quality home environment (Pinto, Pessanha, & Aguiar, 2013). The functional form of the relationship between ECEC quality and developmental outcomes has also been discussed and suggested as a potential explanation for the recurring small effect sizes. Most studies have modeled the relationship between quality and child outcomes linearly, but that this may be a misspecification given that associations have been found to be strongest in the upper-bounds of the quality spectrum (threshold effects) (see Burchinal, Vandergrift, Pianta, & Mashburn, 2010; Hatfield, Burchinal, Pianta, & Sideris, 2016).

Since disadvantaged children tend to benefit substantially from high quality interventions programs, it has therefore been hypothesized that disadvantaged children may also be the ones who most greatly benefit from ECEC at various quality levels. Surprisingly, the empirical evidence does not unequivocally support the notion that quality matters more for disadvantaged children than advantaged children in public ECEC. In favor of the hypothesis, the Effective Provision of Pre-school Education [EPPE] study found that attending ECEC was particularly important for disadvantaged children, as it reduced the chance of developing learning disabilities by 40% within school-age (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2004). This was supported by Dearing, McCartney, and Taylor (2009), who found that children from low income families who had attended above average ECEC quality reduced the gap to their more advantaged peers irrespective of the level of quality these peers had been exposed to. In contrast, two large meta-analyses have cast doubt over whether disadvantaged children benefit more from ECEC quality by failing to replicate such results. Burchinal et al. (2011) found no stronger effects for disadvantaged children in their meta-analysis. The same conclusion was made by Keys et al. (2013) who found little evidence of effects being differentiated by socioeconomic background. In extreme cases where children live under neglectful conditions, disadvantaged children may even be the least likely to benefit from ECEC, since children living under severe stress may have limited benefits of any program until harmful conditions in the home environment have been alleviated (Shonkoff & Fisher, 2013).

1.4.3 Early enrollment, timing of care and universal ECEC

Other than quality, quantity and timing of care are also considered to be central aspects of ECEC that may influence children's development. To some degree these overlap since children who enter early are often also enrolled for a longer period of time before entering school. This is typically the case in Norway, where the vast majority of children are enrolled in full-time ECEC, resulting in somewhat limited variation in quantity of care (weekly hours) (see Eliassen et al., 2018). However, there is nevertheless substantial variation in timing of care both due to national uptake regulations and parental choices. Since the relationship between timing of care and developmental outcomes tends to be confounded by duration of care (quantity) – especially in systems of universal ECEC, I therefore consider these topics together.

The younger the children are when they enroll, the more reliant they are on caretakers that are sensitive to their needs. Thus, outcomes are likely to both depend on the general conditions under which early enrolled children are cared for, but also when and for how long ECEC is provided. If the quality of care provided is high, early enrollment could mean gaining access to more developmentally conducive play, learning and social environments for a longer period of time compared to later-enrolled peers. However, if quality is low, then prolonged exposure to ECEC could be unbeneficial or at worst detrimental to children's development. Additionally, both early entry and quantity may be important factors by themselves – irrespective of quality.

As is often the case, studies on early enrollment and quantity of care have yielded somewhat mixed results. For instance, in a Norwegian quasi-experimental study estimating the effect of early entry on later school performance, Drange and Havnes (2015) found that early enrollment (between 1-2 years) resulted in substantial improvements in language and mathematics ability at age 6-7 years. Promising results of early entry have also been found for infants as young as 9 months old in a British study of 13,000 children, albeit only for children of mothers with low education (Côté, Doyle, Petitclerc, & Timmins, 2013) – although effects had faded within age 5-7 years. Similarly, in another large-scale study (N > 5000) of mostly Dutch children, better language skills were associated with more hours in ECEC – compared to children at home. However, this was only the case for children over the age of 1 year, as infants (< 1 year) were less language proficient the more time they spent in ECEC – at least in the short term (Luijk et al., 2015). Furthermore, and somewhat surprisingly, one study also found little support of poor parenting quality being mitigated by increased time in ECEC (see Adi-Japha & Klein, 2009).

Others have found negative effects of early entry. In a study of advantaged children aged 0-2 years from mostly affluent families in Italy, the researchers found that for every month earlier enrollment, girls lowered their IQ scores by 0.5% (0.045 SD) (Fort, Ichino, & Zanella, 2016). In contrast, a study on low birth-weight children from both high and low income families – where assignment to high quality ECEC was random – showed substantial benefits for disadvantaged children but less so for advantaged children (Duncan & Sojourner, 2013). Several studies have also failed to find any link between early entry and child outcomes. Jaffee, Hulle, and Rodgers (2011) concluded that attending ECEC during the first years of life was neither positive nor negative for children's development. Despite finding between-family differences in academic achievement, there were no within-family differences between siblings who were exposed to different quantities of ECEC care. A similar conclusion was reached by Barnes et al. (2010), who found no effect of quantity of ECEC for children's social competence at age 3 years.

It is worth considering whether effects of quantity or timing of care may differ in systems of universal access compared to countries where ECEC programs are market-driven. The implementation of universal ECEC may also differ substantially across countries, both in terms of hours of care provided per week, level of subsidies and pricing, and which age groups are included. There exists no common definition of universal access outside providing ECEC at an affordable cost and at a capacity that meets demand. However, there are nevertheless commonalities between countries that provide universal access. Typically, attendance rates are high compared to countries that do not provide universal ECEC. Furthermore, some countries with universal ECEC admit children from a very young age – either as infants or toddlers such as Norway and Denmark. Many children enrolled in ECEC within countries that provide universal access therefore tend to experience extensive out-of-home care (quantity) during a sensitive period of their development. Contrary to the extensive literature on the effects of targeted ECEC for preschool-aged disadvantaged children, there have been far fewer studies on the effects of universal ECEC for infants and toddlers due to relatively few countries providing universal ECEC for these age groups. Consequently, many of the studies that have been conducted come from Scandinavian countries that have family-friendly welfare policies, substantial parental leave periods, and high ECEC participation rates (often referred to as the 'the Nordic model') (see Gupta, Smith, & Verner, 2008).

Time spent in ECEC is time away from home. Thus, policies affecting parental leave provide insight into how social reforms that influence the timing and duration of ECEC enrollment for the youngest of children ultimately relate to children's development. Scandinavian countries generally have generous welfare systems, and when parental leave in Sweden was expanded from 12 to 15 months, children were home longer before being enrolled in ECEC. However, only children from well-educated mothers seemed to benefit from prolonged maternal care at home, as children in general did not fare any differently due to delayed entry (Liu & Skans, 2010). Similarly, when Denmark extended parental leave from 14 weeks to 20 weeks long-term educational outcomes were not affected. These children were also notably younger (< 1 year) than those in Sweden due to substantially lower parental leave periods (Rasmussen, 2010). There have also not been found any non-cognitive benefits attributable to universal ECEC in Denmark compared to home care, irrespective of children's gender and family educational backgrounds (Gupta & Simonsen, 2010).

The efficacy of early ECEC has also been assessed more directly. For instance, in a longitudinal study of 1157 children, boys were found to have better language competence at age 4 years the more years they had spent in ECEC – however, the same was not found for girls (Zambrana, Dearing, Nærde, & Zachrisson, 2016). Some have also suggested that extended time in ECEC may result in more behavioral problems (e.g., Gialamas, Mittinty, Sawyer, Zubrick, & Lynch, 2015), but that has not been found to be the case in Norway when selection bias has been mitigated (Dearing, Zachrisson, & Nærde, 2015; Zachrisson, Dearing, et al., 2013). Longer-term effects have also been found. In Sweden, 52 children who were enrolled in ECEC while aged 1.5-3.5 years old and followed in the course of 14 years were found to exhibit positive social competence development associated with their early enrollment (J. J. Campbell, Lamb, & Hwang, 2000).

Outside Scandinavia, the implementation of ECEC policies have also yielded mixed results. In Québec, researchers using a quasi-experimental design found that the increased subsidies that enabled universal access resulted in negative impacts on children's cognitive performance at age 4-5 years – attributed to children spending long hours in ECEC. However, this result is likely to have been due to the quality provided being considered unsatisfactorily low – and particularly poor for children of low educated mothers (Lefebvre, Merrigan, & Verstraete, 2008). For older children, however, results have been more promising – at least when quality is considered to be high. For instance, children attending Oklahoma's universal pre-K program were found to improve in several areas of cognitive development (Gormley, Gayer, Phillips, & Dawson, 2005). Similarly, in an Australian population-based cohort study where ca. 80% of preschool children attended ECEC one year prior to school-entry, ECEC was associated with a variety of positive outcomes both cognitive, non-cognitive and health-related (Goldfeld et al., 2016) even though disadvantaged children were underrepresented. In a study of over one million American children (13 cohorts) who attended North Carolina's relatively high quality state subsidized ECEC programs for various age groups, participation was found to be associated with benefits in later math and reading scores for both disadvantaged (i.e. low-income parents) and non-disadvantaged children (Dodge, Bai, Ladd, & Muschkin, 2017).

The debate over whether public ECEC should be expanded to the level of universal access is ongoing, where some argue that the expansion of subsidized public ECEC programs are ill-conceived altogether since they lack sufficient empirical evidence of efficacy even for disadvantaged children, and are often assessed with measurements of quality that lack both predictive value and validity (Farran, 2016). However, others have dismissed such claims, arguing that there is at least general consensus that when quality is high – ECEC is likely to be beneficial, both in terms of increasing school-readiness and later performance (Hirsh-Pasek, Gustafsson-Wright, Golinkoff, Barnett, & McAlpin, 2016).

1.5 Methodological and theoretical considerations

When reviewing the literature on the impact of ECEC on children's development, it is clear that there is no easy way to summarize across all studies (Duncan & Magnuson, 2013). Perhaps with the exception of the efficacy of targeted high quality ECEC for disadvantaged children, there is no strong consensus on how children enrolled in more publicly available ECEC programs at various quality levels (i.e. universal access) benefit from enrollment – at least for the youngest children (< 2 years). This is partly due to how studies are designed. For instance, experimental studies tend to yield higher effect sizes than non-experimental studies, often due to differences in targeted groups (e.g., advantaged vs. disadvantaged children), quality provided, and length of exposure (duration) (NICHD Early Child Care Research Network & Duncan, 2003). Experimental studies also better account for all aspects of exposure to ECEC – both observed and unobserved – yielding program effects rather than effects of quality measures (observed) which do not capture all ECEC factors that are relevant for child outcomes. Thus, comparing experimental studies conducted on disadvantaged children with observational studies on children enrolled in universal ECEC using observed quality measures is essentially comparing two different things across different counterfactual conditions (see 'The counterfactual causal framework').

The importance of research designs has also been emphasized in a study comparing cognitive outcomes across Head Start programs, where differences in research design features explained 43% of the variation in estimates (Shager et al., 2013). In general, studies with better design quality tend to produce higher effect estimates (Camilli et al., 2010). Although some heterogeneity between studies stems from differing counterfactuals, methodological differences nevertheless play an important role. In the following section, I introduce some methodological considerations and theory behind construct measurement, effect estimation and causal inference – which together provides context for why estimates may vary between studies, and how effective strategies can be devised that mitigate common issues when measuring the impact of ECEC on child outcomes.

1.5.1 How well are constructs measured?

The feasibility of studying the effects of ECEC on child outcomes is largely dependent on how well key constructs have been defined and measured, both in terms of predictors and outcome variables. Poorly measured constructs have low predictive value and therefore do little to *explain* the underlying relationships in question. The applicability of assessment tools is therefore dependent on satisfying conditions of reliability and validity. Assessment tools are said to be reliable if they measure the same thing accurately repeatedly, and valid if they measure what they are intended to measure.

There are two notable schools of thought in the psychometric literature relating to how constructs are measured, as described by Allen and Yen (1979): classical true-score theory and latent trait theory (also called strong true-score theory). In classical true-score theory, test scores represent the sum of two components: a *true* score, reflective of a child's actual ability to solve a task, plus measurement error. An important assumption in classical true-score theory is that the mean of infinitely repeated measurements, where each measurement is theoretically independent of previous measurements, will converge on the *true* score – since measurement error is considered to be random. One implication of this is that the correlation between two variables such as quality and cognitive development can never be perfect (r = 1.0) since scores also include random error; the upper-bound of the relationship is therefore equal to the square root of the reliability of the measure, with the consequence that the true relationship between two variables (e.g., quality and cognitive development) is likely to be substantially underestimated when reliability is low (John & Benet-Martínez, 2014).

Whereas in latent trait theory, a child's test performance is considered to be a function of an unobserved (latent) trait. In essence, latent trait models assign probabilities to children getting a set of questions right depending on the specificities of their abilities (latent traits). Since the observed scores are considered a function of latent traits, hypotheses can be tested about the nature of the relationship between the underlying true score and the observed score distribution (Allen & Yen, 1979). One benefit of this approach is that measurement error can be accounted for through structural equation modeling [SEM] (Schumacker & Lomax, 2000).

1.5.1.1 Measuring cognitive ability

The link between ECEC and children's cognitive development has been attempted assessed by many and springs out of research on general intelligence going back the early twentieth century. Today, intelligence is generally thought of as a structure of subdomains that are linked to a general (higher-order) factor (often referred to as *g*) (see Gustafsson, 1984). However, since intelligence can't be measured directly, it must be done implicitly. Thus, cognitive ability test scores are often seen as a function of some underlying trait (intelligence) – rather than the other way around (Allen & Yen, 1979). Whether cognitive ability assessments measure intelligence in the strictest sense, however, is a matter of debate. Intelligence encompasses many different capacities, whereas most assessment tools arguably measure only a narrow part of one's total capacities. It is also worth noting that some critics have argued that the higher-order structure so often found in intelligence research is a statistical artefact built-in by design (see Detterman, 1982). However, studies using similar hierarchical models for personality traits have found effects to be differentiated by socioeconomic status – suggesting that hierarchical models with a general factor represent actual structures and are not statistical artefacts that are endemic to the scales themselves (Just, 2011).

1.5.1.2 Measuring social competence

Similar to the conceptualization of intelligence and cognition, children's social competence can be thought of in terms of latent characteristics. However, a variety of definitions of social competence exist. Some rating scales include externalized behavior such as aggression and disobedience, lack of behavioral control, in addition to aspects relating to self-control such as controlling temperament, accepting peer ideas, responding appropriately - and typically assess adult defined levels of being well-behaved (Huston, Bobbitt, & Bentley, 2015). In contrast to studies focusing on internalizing or externalizing behavior, where children are assessed on problematic behavior that is disruptive to the social environment (externalizing) (see Fisher & Lerner, 2005), or behavior symptomatic of anxiety, depression, or social withdrawal (internalizing) (see Cicchetti, 2016) – social competence can be seen as traits or skills along a more positive axis and understood as 'effectiveness in social interaction' (Rose-Krasnor, 1997).

Children's social competence can be seen as a subset of skills relating to their socio-emotional development. These skills include the ability to 1) develop positive relationships with others, coordinate and communicate actions and feelings with others, and 3) recognize and regulate emotions and actions when interacting with others (S. B. Campbell et al., 2016). A number of assessment tools have been developed to measure and assess children's social competence, such the Lamer Social Competence in Preschool scale (Lamer, 1997), or the Social Skills Rating System [SSRS] (Gresham & Elliott, 1990). However, the lack of consensus on a common operational definition of 'social competence' makes it difficult to compare effects across studies (Rose-Krasnor, 1997).

1.5.1.3 Measuring quality

As mentioned previously, one simple definition of ECEC quality is a center's defining characteristics that either directly or indirectly promote a preferred outcome. Standardized quality assessment tools rely on the assumption that quality is not local, and that the same level of quality is likely to produce equivalent results in a different context. Another assumption is that standardized quality assessment tools actually measure what is important. If only factors that are simple to observe are measured, but which are not predictive of any outcomes, scores can misrepresent the *true* quality of ECEC centers. Furthermore, many widely used measurement tools of quality such as ITERS-R have not been developed with psychometrics in mind, and the validity of the scales may therefore not have been fully assessed statistically. It has been argued that scales currently in use today are useful in differentiating high quality centers from poor quality centers, but lack discrimination in mid-range (Burchinal, 2017).

1.5.2 Causal estimation

Do children who enter ECEC early resemble the ones who enroll later on? Do they have similar family backgrounds? Are children from highly-educated families more likely to be enrolled in higher quality ECEC centers than children from lower educated families?

A problem with the early childhood education and care literature – and educational research in general – is that it is mostly based on observational data. Seldom is it possible to conduct experiments by randomized controlled trials (RCTs) to help settle questions of causality. If ECEC enrollment was random, it would be possible to probabilistically account for both observed and unobserved differences (bias) between child groups. However, outside targeted interventions, ECEC participation is not likely to be random. Most parents make choices related to which centers to apply to, and when to enroll their children. These choices are likely to induce bias since parental preferences might be linked to socioeconomic characteristics which in turn may confound the relationship between children's age of entry into ECEC and child outcomes. For instance, highly educated parents may be more likely to enroll their children early into ECEC than lower educated parents – or vice versa.

However, compared to many other countries, selection bias may be less prominent in Norway due to very high attendance rates. Considering that over 90% of all children attend ECEC prior to school age means that very few families choose not to – resulting in a wide variety of socioeconomic backgrounds being represented in ECEC. Although most children end up being enrolled eventually, not all of them enter at the same time. Thus, children's entry age is likely to be affected by selection bias since some parents may decide to wait longer to enroll their children than others, or conversely try to enroll them before having a legal entitlement. This also appears to be the case, as socioeconomically disadvantaged families have been found to be more likely to delay enrollment (Zachrisson, Janson, et al., 2013). Since bias often cannot be convincingly ruled out, effect estimates from observational studies are generally considered to be correlational rather than causal.

1.5.2.1 The counterfactual causal framework

The counterfactual framework (also known as the potential outcomes framework), can be described as a thought experiment of what would have happened if what did happen had not happened. For instance, what would have happened had the children who entered ECEC early instead had to wait? In circumstances with a dichotomous 'treatment' condition where a child either enrolled early or it did not, the causal effect (δ) under the counterfactual model would equate to the difference between the expected outcome of Y for child i under 'treatment' condition 0 (entered early) and the expected outcome of Y for child i under 'treatment' condition 1 (did not enter early). More formally, this can be expressed as:

$$E[\delta_i] = E[Y_i^0] - E[Y_i^1].$$

Or simply:

$$\delta_i = y_i^0 - y_i^1.$$

However, only one outcome is ever possible and observable since children either enter early or they do not. Consequently, the causal effect of entry age cannot be obtained for each individual child, but an average causal effect across groups can nevertheless be obtained by modeling the relationship between children exposed to different 'treatment' conditions (e.g., early enrollment vs later enrollment) under defendable assumptions (Morgan & Winship, 2007).

1.5.2.2 OLS regression

Ordinary least squares [OLS] regression is the most frequently used statistical technique to tackle problems related to omitted variable bias (and selection bias) when analyzing observational data. The technique enables 'controlling' or 'adjusting' for potential confounders by including covariates in the regression equations; confounders are variables that influence both the predictor and the outcome, and if left unaccounted for, will bias the estimated relationship between the predictor and the outcome regardless of sample size (Kennedy, 2008). By this approach, the estimated effect of a treatment can be expressed as the expectation of outcome y conditional on treatment x, holding covariates c fixed:

$$E[y|x,c]$$

which in linear algebra equates to the regression equation:

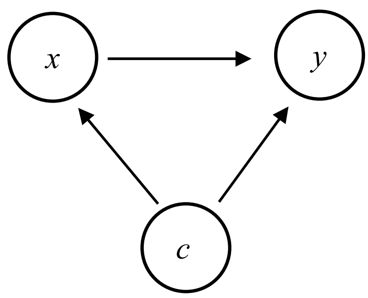
$$y = \alpha + \beta x_1 + \ldots + \beta x_n + \varepsilon$$

where y is the outcome; α is the intercept; β is the slope for each $x_1 \ldots x_n$; and ε is the error. A causal estimate can be obtained under the strict assumption that the expectation of the error, conditional on covariates, is zero (see Hayashi, 2000; Wooldridge, 2002):

$$E[\varepsilon \mid x] = 0.$$

Said differently, predictors must be exogenous (uncorrelated with the error ε) in order for estimates to be unbiased. However, arguing that this assumption is satisfied in non-experimental cases is hard to do convincingly, since it implies that all important variables (confounders) have been measured, measured well, and have been included in the regression equation (see Fig 2).

Fig. 2. Causal diagram of the effect of *x* on *y* conditional on *c*



Note: *c* denotes a vector of all confounders. Arrows denote direction of influence between variables.

1.5.2.3 Instrumental variable analysis

Instrumental variable analysis (IV) is a statistical technique that enables estimation of causal effects from non-experimental (observational) data. The technique is relatively uncommon within psychological and educational research, but widely used within the field of econometrics. The novelty of IV analysis is that rather than condition on covariates such as in OLS regression analyses, IV circumvents the problem of omitted variable bias by using a so-called instrumental variable (instrument) to remove problematic variation (bias) in an endogenous predictor, and subsequently use the ‘purged’ version of the predictor to estimate the treatment effect. A predictor is said to be endogenous if it is correlated with the error (ε).

In an IV regression framework, causal estimates can be obtained using the following two-step procedure:

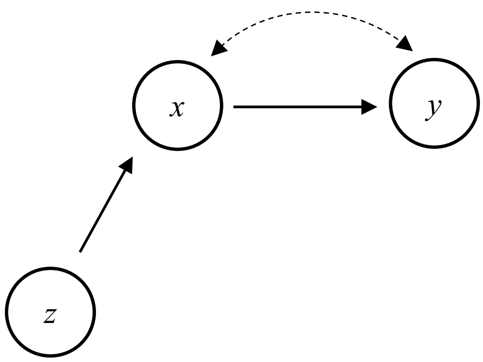
$$\hat{x} = \alpha + \beta z + \epsilon \quad (1)$$

$$y = \alpha + \beta \hat{x} + \epsilon \quad (2)$$

Where we first obtain the predicted values of the endogenous variable (x) using an instrumental variable (z) in the first-stage equation (1), and subsequently use the predicted values of x ($\hat{x}$) as a predictor in the second-stage equation (2). (Typically, estimation is done in one step with software using the two-stage least squares estimator [2SLS] in order to get correct standard errors (Angrist & Pischke, 2008)).

In a structural equation model [SEM] framework, the equivalent causal effect of x on y can be obtained by regressing y on x, x on z, and correlating the residuals between x and y (see Fig. 3).

Figure 3. Causal diagram of the effect of x on y using z as an instrumental variable



Note: x denotes the endogenous predictor; y denotes the outcome; z denotes the instrumental variable; one-sided arrows denote regressions; double-edged arrow (dashed line) denotes correlated residuals.

The IV estimator produces estimates that are asymptotically unbiased (i.e. converge on the population mean in large samples) (Kennedy, 2008). These causal estimates are valid for a specific portion of the sample, and typically referred to as a local average treatment effect

[LATE]. Specifically, LATE is the causal effect for all children who are affected by the 'treatment' status as caused by change in the instrumental variable.

However, the validity of the causal estimates hinges upon satisfying two key assumptions. First, the correlation between the instrument and the endogenous predictor has to be strong; weak instruments are prone to bias (Bound, Jaeger, & Baker, 1995; Staiger & Stock, 1997; Stock & Yogo, 2002), and may potentially produce more biased estimates than what would have been obtained using OLS regression (hence the *cure* being worse than the *disease*) (Bound, Jaeger, & Baker, 1993). Second, there must also be no direct effect of the instrument (z) on the outcome (y), only an indirect effect through the endogenous predictor (x). In other words, the instrument must not suffer the same endogeneity problem it is meant to solve. However, finding good instruments can be difficult and is not always possible. Influential uses of instrumental variable analysis include rainfall variation as an instrument for the effect of economic shocks on civil conflict (see Miguel, Satyanath, & Sergenti, 2004), distance to college as an instrument for the effect of schooling on later earnings (see Card, 1993), and quarter of birth as an instrument for the effect of schooling on earnings (see Angrist & Krueger, 1991).

1.6 Research aims of the present dissertation

In this dissertation, we studied the effects of early life conditions in universal ECEC on children's cognitive and social competence development at age 3 years. Specifically, we focused on the quality of care provided and children's entry age. In the case of the latter, we were able to capitalize on a 'natural experiment' that allowed for estimating the impact causally. The difficulty of this normally lies in how parents are likely to try to influence when their children are enrolled – making entry age an endogenous variable (i.e. affected by selection bias) and resulting in biased estimates under OLS. However, due to the regulations requiring children to have turned 1 year within September 1. in order to be legally entitled to enroll, there should be exogenous variation in entry age depending on when the children are born; the relationship between children's entry age and their birth month was expected to be strong but was nevertheless not expected to be perfect since parents are not prohibited from trying to enroll their children into centers where there is extra capacity, prior to obtaining a legal right. We argue that children's birth month is a plausibly exogenous instrument as it is unlikely to be directly linked to child outcomes (i.e. cognitive and social competence) since 1) child characteristics are likely to be evenly distributed across birth months, and 2) mothers are unlikely to be able to time their births to the degree that significantly biases results. The validity of time-of-year-of-birth instruments has been argued for in several methodologically similar studies, notably by Angrist and Krueger (1991), and more recently by Dearing et al. (2015) who used children's birth month to estimate the effect of entry age on children's aggression in a population of Norwegian children.

1.6.1 Paper I

In Paper I, we assessed the relationship between ECEC quality and children's cognitive development at age 3 years. We also hypothesized that the importance of quality might differ for children of various socioeconomic backgrounds, and therefore tested for interaction effects. We accounted for selection and omitted variable bias with simple covariate adjustment using ordinary least squares regression models.

1.6.2 Paper II

In Paper II, we assessed whether children's age of entry into ECEC had a causal effect on their cognitive development (verbal and non-verbal) at age 3 years using instrumental variable analysis. We used children's birth month as an instrument in order to partial out exogenous (i.e. random) variation in children's entry age into ECEC, and subsequently compared causal estimates with ordinary least squares regression estimates for reference.

1.6.3 Paper III

In Paper III, we assessed whether children's age of entry into ECEC had a causal effect on their social competence at age 3 years. Expanding on the IV methodology from Paper II, we embedded the instrumental variable analysis within a structural equation modeling framework – using birth month as an instrument. With this approach, we were able to estimate the causal effect of entry age while also taking into account measurement error in the social competence outcome.

2 Methods and Materials

2.1 Samples, procedures and data sources

We used data from the Better Provision for Norway's Children in ECEC (BePro / GoBaN) project – one of the largest research studies conducted within early childhood education and care in Norway.

2.1.1 Data sources

BePro / GoBaN is an ongoing longitudinal research project with an overall aim of assessing the quality of Norwegian ECEC and its implications for children's cognitive and social competence development. In total, over 90 centers are represented in the study, and more than 200 'classrooms'. These were randomly drawn from a pool of public and private ECEC centers which were located in proximity to a university or university college. In total, 7 counties were represented (Akershus, Nordland, Oslo, Rogaland, Telemark, Troms and Vestfold). All parents of eligible children within each participating center were invited to participate. Ca. 1200 children, born in 2011 (56%) and 2012 (44%), were recruited to the project. Written consent was provided on behalf of the children by parents or legal guardians (for complete details, see Bjørnestad, Gulbrandsen, Johansson, & Os, 2013). During the 5 year-period the project has been running, some participants have withdrawn from the study (ca. 21% attrition), but most of these withdrew due to moving and/or changing ECEC center. Only a minor proportion of children (estimated < 5%) withdrew for reasons that may be linked to the research project itself. Assessments of center quality were conducted by trained personnel or researchers who were reliable above 80%-level, in accordance with recommendations (see Harms, Cryer, & Clifford, 2006). Children were assessed on both cognitive ability and social competence. Cognitive assessments were conducted by trained data collectors who visited the ECEC centers ahead of time in order to become acquainted with the children before the assessments were conducted. Participation was voluntary, but very few children were reluctant. The two cognitive assessments were conducted in random order, in order to avoid systematic bias from potential loss of concentration over time. The children were accompanied by a trusted teacher or assistant to make sure they felt relaxed and at-ease. Social competence was assessed by the children's teachers. Information on family background was also retrieved through self-reported questionnaires (electronic) or in the form of structural interviews conducted by trained personnel or researchers. All assessments and data collections were conducted when the children were approximately age 3 years. The project was approved by the Norwegian Data Protection Authority, in accordance with ethical guidelines.

2.1.2 Study samples

2.1.2.1 Paper I

In Paper I, the analytic sample included 800 children, recruited from 83 ECEC centers.

2.1.2.2 Paper II

In Paper II, the analytic sample included 509 children, born between February and August, with an entry age prior to age 2 years, who were recruited from 87 ECEC centers. This was a subset of a sample of 787 children that were born throughout the year.

2.1.2.3 Paper III

In Paper III, the analytic sample included 478 children, born between February and August, with an entry age prior to age of 2 years, who were recruited from 81 ECEC centers. This was a subset of a sample of 745 children that were born throughout the year.

2.2 Measures

2.2.1 Cognitive ability

Cognitive development was measured using the British Ability Scales III (BAS3) (Elliot & Smith, 2011). We used two assessments from a larger set: one for verbal ability and one for non-verbal ability. Verbal ability was measured with the 'naming vocabulary' subscale. This assessment consisted of children being shown a sequence of cards – one by one – depicting mostly everyday objects (e.g., boat, scissors, house) and subsequently asked to name them. The non-verbal cognitive ability assessment was measured with the 'picture similarities' subscale. Similar to 'naming vocabulary', children were showed a sequence of cards depicting different objects. But rather than name the object, the children were asked to match the object on their given card with one out of four alternative objects on a board. The purpose of the task was to assess whether children were able to reason which objects go together – by having a shared element or concept (e.g., boat and water, stamp and envelope, rain and umbrella).

On both assessments, children were allowed one attempt at each question (item). Each correct answer was scored as one point, and each wrong answer was scored as zero. Children were encouraged and praised regardless of their answer. After completion, raw scores (total scores) were calculated by taking the mean across all given items. However, due to the way the assessment scales were designed, all children did not receive the same number of items (tasks) to solve; low performing children were scored off earlier than high performing children. In order to adjust for this inherent bias, raw scores were standardized into 'ability scores' in accordance with the BAS III scoring manual (see Elliot & Smith, 2011). Essentially, this corrected for the number of items administered by giving weight to children who were administered fewer items to solve. To reduce the chance of other types of bias, the verbal and non-verbal ability assessments were given in random order to avoid children's potential loss of interest or concentration to affect performance on either of the two assessments disproportionately. We also note that children were given a translated version of the verbal ability assessment (originally in English). This translated version of the assessment has not been validated in previous samples. The potential implications of using a translated assessment rather than the original should be taken into consideration. For instance, the sequential order of the questions (items) given should increase in difficulty throughout the assessment, corresponding to the assumed familiarity with the depicted object but also due to the complexity of the objects' names. However, the complexity of a word in English does not necessarily match the same level of complexity translated into Norwegian. Consequently, this may disrupt the rank order of the verbal ability assessment.

2.2.2 Social competence

To measure children's social competence we used the Lamer Social Competence in Preschool scale (LSCIP) (Lamer, 1997; Lamer & Hauge, 2006), developed by Kari Lamer and inspired by the Social Skills Rating System (SSRS) (see Gresham & Elliott, 1990). The scale is well-known in Norway and used by both practitioners (see Gulbrandsen & Eliassen, 2013) and researchers. In its original form, the scale consists of 31 items grouped into 6 categories / dimensions: 1) assertiveness, 2) self-control, 3) empathy and role-taking, 4) play, joy, and humor, 5) prosocial behavior, and 6) adjustment. Scoring is conducted on a 5-point Liker-scale from least to most favorable (1 = very rarely, 2 = rarely, 3 = occasionally, 4 = often, 5 = very often).

There have been conducted relatively few studies assessing the psychometric properties of the scale. The first evaluation was done by Lamer and Hauge (2006) who tested the originally proposed factor structure of 6 factors. More recently, Midteide Løkken, Broekhuizen, Moser, Bjørnestad, and Meyer Hegna (2018) tested the same model (with a few minor adjustments) in a new sample, in addition to a model with 3 factors. However, neither the 6-factor solution (TLI = 0.883, CFI = 0.896, RMSEA = 0.055) or the 3-factor solution (TLI = 0.832, CFI = 0.846, RMSEA = 0.066) were found to be good. However, a bi-factor solution has since been proposed by Zachrisson, Janson, and Lamer (2018) – with a general factor (social competence) and 3 group factors (play / assertion, self-control, & empathy) – which was shown to have adequate fit and was consequently the model of choice in our study (Paper III).

2.2.3 Quality

ECEC quality was measured with the Infant/Toddler Environment Rating Scale Revised Edition (ITERS-R) (Harms et al., 2006). ITERS-R comprises 39 items grouped into 7 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. Each subscale is thought to represent one aspect of quality. However, the idea that ITERS-R captures several different dimensions of quality for infants and toddlers has been contested. Factor analyses conducted by Bisceglia, Perlman, Schaack, and Jenkins (2009) has indicated that ITERS-R is more likely to represent one general quality dimension rather than 7 distinct dimensions. The scale is mostly a measure of structural quality, but also includes elements relating to process quality. Scoring is done on a 7-point scale (1 = 'inadequate', 3 = 'minimal', 5 = 'good', 7 = 'excellent'), and each item has its own score. Items are scored based on information on the indicator level which contains the lowest level of information within ITERS-R. These indicators are typically ordered from most basic requirements to more sophisticated quality aspects. Often these indicators represent whether something is present or not (e.g., whether the children have access to books or learning material, etc.). Item scoring is conducted in a hierarchical logic, where the presumed most basic indicators need to be satisfied in order to score higher level indicators.

Despite its wide use, there have been conducted few psychometric evaluations of the scale. However, one such study (on the item-level) found it to measure one global quality factor (Bisceglia et al., 2009). Similar conclusions of single-factor solutions have been made by researchers assessing ECERS (Perlman, Zellman, & Le, 2004) which closely resembles ITERS-R but is intended to measure ECEC quality for preschool-aged children. Due to these assessments, we used the ITERS-R total scores as a measure of overall center quality by taking the mean across all items from subscales 1-6 (subscale number 7, 'Parents and staff', was excluded since items under this subscale do not relate directly to provision for children).

2.2.4 Covariates

We included a variety of covariates in our statistical models. Family background variables were retrieved from the parental questionnaire, including maternal and paternal education (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, 6 = other); highest attained education in the family; household income (gross annual income in NOK); mother's weekly work hours; father's weekly work hours; ethnicity (dichotomized as Norwegian/non-Norwegian); how often parents read, and played number and letter games with their children; children's birthweight; age of entry into ECEC; number of siblings; time spent in ECEC per day; days spent in ECEC per week. Additional variables from other sources were also included: children's age at assessment was calculated from birth date and recorded time of assessment; gender was derived from personal identification numbers; municipality / region (dummy coded); child care center (dummy coded); and center quality was measured with ITERS-R.

2.3 Statistical approaches

Several statistical techniques were used for parameter estimation in Papers I-III, and all address the problem of omitted variable bias (and selection bias) albeit in different ways. Analyses were done in the open-source statistical software package R (R Core Team, 2016).

2.3.1 Paper I

In Paper I, we used ordinary least squares regression (OLS) to estimate the effect of ECEC quality for children's cognitive development, while adjusting family background factors and a variety of covariates. We also tested for differential effects between socioeconomic subgroups by including interaction terms in the models ($Quality \times Income$ & $Quality \times Education$). Last, we checked whether there was parental selection into ECEC based on center quality by regressing ECEC quality on family background characteristics.

2.3.2 Paper II

In Paper II, we used instrumental variables analyses [IV] to estimate the causal effect of children's entry age on social competence development and used OLS regression as reference. In the IV analyses, we used children's birth month as an exogenous instrument since children's entry age can partly be predicted from their birth month.

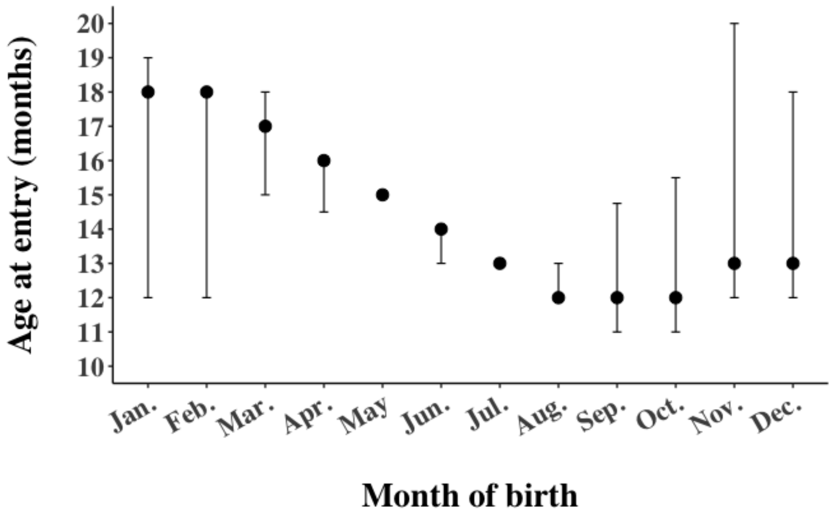
As stated in the introduction ('Instrumental variable analysis' section), two key assumptions need to be satisfied in order for valid causal inference to be made. The first assumption is that the instrument is strongly related to the endogenous predictor (entry age). Instruments are generally considered strong if the first-stage *F*-statistic exceeds 10 (Stock, Wright, & Yogo, 2012); if the *F* value is larger than 10, then the bias in the causal estimate should generally be less than 10% compared to OLS (Kennedy, 2008). The second assumption – often referred to as the exclusion restriction – implies that there must be no direct effect of the instrument on the outcome, only an indirect effect through the endogenous predictor (Angrist, Imbens, & Rubin, 1996). Although the first assumption regarding instrument strength can be tested, the second assumption is untestable since the estimated equations include unobserved errors that cannot be accounted for – we must instead rely on logical argument (Kennedy, 2008; Murnane & Willett, 2011).

In order to ensure instrument strength and validity, some adjustments needed to be made. Since ECEC uptakes are mostly in September, and the right to enrollment is granted children who have turned one year old within September 1., it is clear that for birth month to be a linear predictor of entry age, then the coding of each birth month as a rising number from January to December does not work (i.e. 1 = Jan., 2 = Feb., 3 = Mar., 4 = Apr., 5 = May, 6 = Jun., 7 = Jul. 8 = Aug., 9 = Sep., 10 = Oct. 11 = Nov., 12 = Dec.). With this coding, birth month is only a linear predictor of entry age from January to August, since children born between September and December would have lower expected entry ages rather than higher – compared to children born between January and August.

One way to correct this could have been to recode each birth month, starting from September (1 = Sept., 2 = Oct., 3 = Nov., 4 = Dec., 5 = Jan, 6 = Feb., 7 = Mar., 8 = Apr., 9 = May, 10 = Jun., 11 = Jul., 12 = Aug.). From this recoding, we would expect a linearly falling entry age for each passing month starting from September and ending in August, as would be the case had the September 1. rule been strictly enforced and if children were unable to obtain a place in ECEC before they were legally entitled. However, as can be seen from Figure 4, there were substantial deviations from this pattern for children born between September-January. Note that these deviations do not weaken the validity of the causal design, only that the instrument strength decreases if children from all birth months are included. To ensure a strong instrument, we therefore used the approach taken by Dearing et al. (2015), by only including children born between February and August – and excluding the rest.

Second, we excluded all children who had an entry age above 24 months. This was necessary to ensure causal validity since all children should have been offered ECEC enrollment within age 2 years due to national uptake regulations (as described under 'ECEC in Norway' section). Children who nevertheless had an entry age later than 2 years were therefore considered to come from families that had deliberately delayed their enrollment – and would consequently introduce selection bias that could not be mitigated by our instrument.

Figure 4. Distribution of children's entry age into ECEC across birth months



Note: Dots denote the median entry age within each month; bars denote the 25/75th percentile.

To estimate the IV models we used the two-stage-least-squares [2SLS] estimator with AER/ivreg in *R* (Kleiber & Zeileis, 2008). OLS models included a full set of covariates, while IV models included covariates only in the robustness checks.

As a final step to prevent bias, we estimated fixed effects models for both OLS and IV models, allowing us to control for heterogeneity in ECEC centers – deriving estimates from within-center variation rather than within and between-center variation. This was done by including dummy variables for each center (minus a randomly selected reference category), and effectively controlled for both observed and unobserved variation in ECEC center quality across different locations under the assumption that there is sufficient within-center variation (on average there were ca. 7 children per center, with a standard deviation of 4.6).

We also tested for endogeneity using a Wu-Hausman test which tests for consistency between estimators under the null hypothesis that both OLS and IV are consistent. If estimates are consistent, both estimators produce essentially the same asymptotically unbiased estimates (Kennedy, 2008).

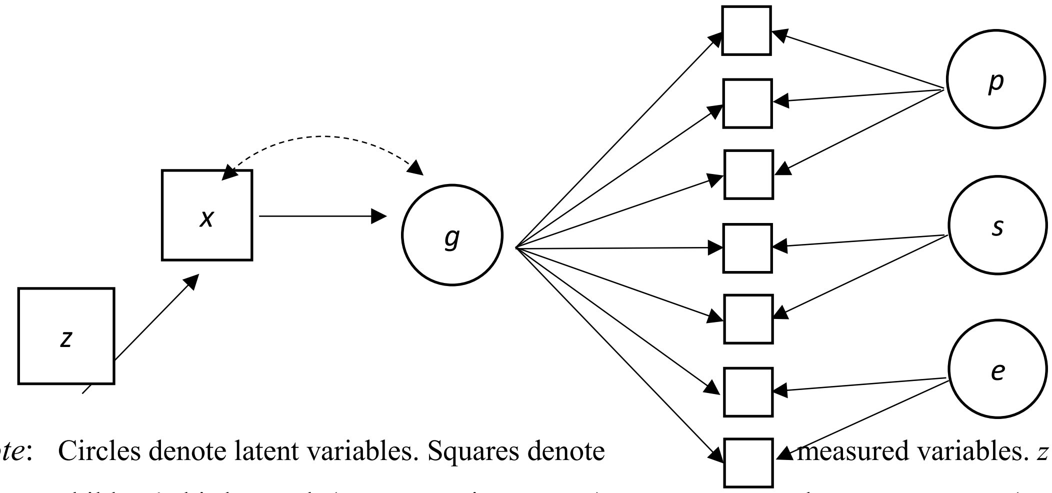
2.3.3 Paper III

In Paper III, we embedded the IV approach from Paper II – as described above – within a structural equation modeling framework [SEM]. This had the benefit of building on the theoretical causal framework from Paper II, while enabling us to model social competence as a latent variable. As described by Ullman and Bentler (2003), SEM enables simultaneous estimation of multiple regression equations, and typically consists of two parts: a measurement model and a structural model. The measurement model is the part that relates the observed variables (e.g., the assessed items) to the latent factors, whereas the structural model is the part that hypothesizes the relationship between the latent factors. Since SEM allows for hypothesis testing with latent factors rather than just observed (measured) variables, random measurement error can be accounted for (see Schumacker & Lomax, 2000).

In Paper III, we used a specific type of model called bi-factor model. Bi-factor models are characterized by having a general factor that loads on all items, as well as domain-specific factors that load only on some items. The benefit of the bi-factor model is that it makes it possible to assess the impact of the general factor on observed variables while also being able to evaluate the individual contributions of the domain-specific factors (Church, 2010). In the measurement model, we therefore hypothesized the construct of social competence – in the context of the LSCIP scale – to consist of one general social competence factor (*g*), and three domain-specific factors (*p*, *s*, *e*), where one related to 'play / assertion' (*p*), one related to 'self-control' (*s*), and one related to empathy (*e*) (see Fig. 5).

After specifying the measurement model, we addressed the predictive component of the model. We hypothesized that children's general social competence (*g*) had been influenced (causally) by their age of entry into ECEC (*x*). Since we considered entry age to be an endogenous variable (e.g., affected by parental selection), we only wanted to use the (exogenous) variation in entry age that could be predicted from children's birth month (*z*) which was used as an exogenous instrument. As stated in introduction (see 'Instrumental variable analysis' section), this was achieved by regressing entry age (*x*) on birth month (*z*) and co-varying the residuals between entry age (*x*) and general competence (*g*) – as shown in Fig. 5.

Figure 5. Bi-factor SEM of causal effect of entry age on social competence



Note: Circles denote latent variables. Squares denote measured variables. *z* denotes children's birth month (exogenous instrument), *x* denotes entry age (endogenous predictor), *g* denotes general social competence factor; *p* denotes 'play / assertion' factor; *s* denotes 'self-control' factor; *e* denotes 'empathy' factor. One-sided arrows denote regressions, double-edged arrows (curved and dashed) denote correlated residuals. Small (empty) squares denote individual items from the questionnaire. Due to the high number of individual measurement variables from the LSCIP scale, the specific items that factors *g, p*, *s*, *e* load on are not specified but rather conceptually illustrated. The full model specification of the measurement component can be found in Paper III.

To estimate the model, we used the robust maximum likelihood estimator (robust ML) with *lavaan* and *lavaan.survey* in *R* (Oberski, 2014; Rosseel, 2012), which corrected for cluster-correlated errors. A trade-off of using robust ML (or ML) to estimate results was that measurement variables had to be treated as continuous rather than ordinal (a software limitation in the *lavaan* / *lavaan.survey* pair). We recognize that using the WLSMV (Weighted Least Squares Means and Variance adjusted) estimator on categorical data would have been preferable had this option been available.

To assess model fit (i.e. how well the model reproduced the variance/covariance matrices of the actual data), we evaluated and reported the root mean square error approximation (RMSEA), standardized root mean square residual (SRMR), comparative fit index (CFI), and Tucker-Lewis Index (TLI). We evaluated model fit in light of popular guidelines (see review by Hooper, Coughlan, & Mullen, 2008).

2.3.4 Robustness checks

Since model estimates can be (and often are) sensitive to model specifications, it is generally a good idea to test their robustness to check whether alternate specifications change the effect sizes substantially (see Neumayer & Plümper, 2017). We used similar robustness checks throughout all papers, but robustness checks were particularly important in Paper II and Paper III since models were argued to represent causal relationships. We therefore checked whether the IV estimates were sensitive to the inclusion of potentially important covariates (e.g., parental education). If causal estimates were indeed sensitive to the inclusion of covariates, then this would imply that the instrument (birth month) would not be unconditionally exogenous (valid) since these would represent alternative pathways between the instrument and the outcomes. Although such confounders could be controlled for in the same manner as in traditional regression, they would nevertheless weaken the argument of instrument validity as other unmeasured confounders could also exist. Conducting robustness checks that included covariates in the IV models therefore provided important information on the validity of the causal design.

2.3.5 Missing data

When data is missing, it needs to be handled. However, there are different ways of doing so, most of which need to be justified under the conditions that data are either missing at random (MAR), or missing completely at random (MCAR) (see Allison, 2001). We used the following three techniques to handle missing data. When missing cases were few, we used listwise deletion, a technique where individuals with some missing data on an included variable were completely omitted from the analyses. When missing cases were more prevalent, we used regression imputation to impute the most probable values based on other background information such as parental education. When missing values were more of an issue, we used multiple imputation with *MICE* in *R* (van Buuren, 2011) which makes it possible to account for the uncertainty in the imputations to produce accurate standard errors under the assumption that missing values are MAR or MCAR (Azur, Stuart, Frangakis, & Leaf, 2011).

Missing data was not a major issue in Paper I and Paper II (cognitive outcomes). Most data were complete, and few children did not want to participate. However, on the social competence outcome, the data contained instances of missing data. We were informed that some teachers found some of the questions in the questionnaire hard to answer due to the children's young age and were therefore left unanswered. Due to having such an extensive questionnaire (ca. 30 questions per child), the likelihood of at least one question not being answered were therefore quite high. Although these instances of missing values were relatively few in total, they were spread out in a way that ca 15% of the children were registered with at least one instance of missing data on the social competence outcome. If these cases were not imputed, the sample size would have been reduced by 15% with listwise deletion.

2.3.6 Outliers

Outliers are values which are extreme within the sampled distribution and can exert a strong and disproportionate influence on effect estimates if left undealt with. However, how to best deal with outliers has been vigorously debated (see V. Barnett & Lewis, 1980). Simply removing them is often considered unwarranted. Instead, we opted to restrict their pull on the estimates by limiting their range while preserving their rank order – a technique known as winsorization (see Ghosh & Vogt, 2012). Essentially, this is done by replacing values above the 95th percentile with values at the 95th percentile, and similarly replace values below the 5th percentile with values at the 5th percentile.

2.3.7 Clustering

Children within groups are more likely to be similar than children between groups, due to reciprocal peer-influence and by living in areas with certain socioeconomic commonalities. However, this also implies a potential violation of one of the assumptions of regression, namely that model errors are independent. When children are nested in groups, errors are likely to be independent between groups, but correlated within groups– resulting in incorrect standard errors of the estimates. To correct for this, we used cluster-robust regression estimation at center level (see Cameron & Miller, 2014).

3 Results

3.1 Paper I

In Paper I, we studied the relationship between ECEC quality – as measured with ITERS-R – and children's verbal and non-verbal cognitive development at age 3 years. We also assessed whether results varied depending on socioeconomic background (parental income and education level). The study sample included 800 children from 83 centers. We found no main effect of quality on children's cognitive abilities using traditional OLS regression analysis, adjusting for covariates. Children who attended higher quality ECEC centers were not more likely to do better than children who attended lower quality ECEC centers. Nor was the relationship between ECEC quality and cognitive performance moderated by socioeconomic background, as children of parents with lower education and/or income performed neither better nor worse depending on the quality of care provided compared to their more advantaged peers.

3.2 Paper II

In Paper II, we studied the causal effect of age of entry into ECEC and children's verbal and non-verbal cognitive development at age 3 years. We analyzed data from 509 children with an entry age into ECEC prior to 24 months. Causal estimates were obtained by *partialling* out exogenous variation in entry age using children's birth month in an instrumental variable (IV) design. We found that entry age had a direct impact on children's cognitive development. For each month earlier enrollment – between the age 10-23 months – children were predicted an additional 14.1% of a standard deviation ($p < 0.001$) higher score on non-verbal cognitive ability. However, the same was not found for verbal ability, as children who entered early did not score better than children who entered later ($B = -0.024$, $p > 0.5$). By comparing estimates between OLS and IV, we found that traditional covariate adjustment techniques were inconsistent when estimating the effect of age of entry into ECEC on non-verbal abilities – but not verbal abilities, as also evident by results on the Wu-Hausman test of endogeneity.

3.3 Paper III

In Paper III, we assessed the causal effect of children's age of entry into ECEC on social competence at age 3 years. Expanding on the statistical approach from Paper II, we found that entry age also affected children's social competence. However, contrary to the findings in Paper II, entry age had a negative effect on children's social development. A standard deviation earlier enrollment predicted 32% of a standard deviation lower social competence score at age 3 years ($p < 0.01$). The social competence outcome was modeled as a latent outcome variable using structural equation modeling [SEM]. We found that a bi-factor solution of the Lamer Social Competence in Preschool scale [LSCIP] provided good fit (RMSEA = 0.059; SRMR = 0.056; CFI = 0.909; TLI = 0.896). The causal (IV) estimates were robust to the inclusion of covariates, as expected, providing support for the assumption that children's birth month is an exogenous instrument.

4 Discussion

In this dissertation, we have addressed the relationship between ECEC factors and children's cognitive and social competence development at age 3 years, using several different statistical techniques. In summary, we found that 1) ECEC quality did not predict children's cognitive development – irrespective of socioeconomic backgrounds, 2) lower entry age positively affected children's non-verbal ability but had no impact on verbal ability, and 3) lower entry age negatively affected children's social competence.

4.1 The importance of quality for child development

The lack of relationship between ECEC quality and cognitive development at age 3 years (Paper I) calls into question whether quality matters for the demographic of children that were sampled. Neither children in general, nor those of presumed disadvantage (i.e. having parents with low income and/or education) showed any signs of their verbal or non-verbal performance being linked to the level of quality they received in their respective ECEC centers. Thus, we did not find evidence in support of the frequently posited hypotheses that 1) disadvantaged children have most to gain from quality due to the compensatory role of ECEC, 2) advantaged children have most to gain from quality due to the cumulative benefits of being advantaged, or that 3) high quality is better than low quality when it comes to promoting children's cognitive development. However, not only do these findings run contrary to intuition given what we know about the importance of being exposed to a stimulating social environment (e.g., Fox et al., 2010; Knudsen, 2004), they also to some degree contrast previous studies finding small but significant effects of quality (see review by Burchinal et al., 2011).

4.1.1 Construct validity of ITERS-R as a measure of quality

One reason for why quality does not seem to matter (or matters little) for this group of children is that ITERS-R may not be measuring what is actually important for children's development. If 'quality' as a construct is not well measured, we would expect it to have low predictive value (producing weak or no correlations). The weak correlations found between ITERS-R and child outcomes in previous studies may provide some indication that quality is indeed not well-defined, at least not in terms of capturing dimensions related to children's cognitive development. In part, this may be due to the way ITERS-R quality scores are calculated – as the mean across a large set of items from multiple domains. If only some of these items are relevant for child outcomes, then the composite quality measure (total score) contains noise which reduces its predictive value. That ITERS-R contains a multitude of items which not only relate to child outcomes is also implied by Zaslow et al. (2016) who found that when domain-specific indicators related to child interaction quality were included as predictors in regression models, there were no longer significant main effects of global quality (total score). The low predictability of ITERS-scores is likely a reflection of not having been developed for research purposes with the aid of psychometric assessments, but rather as a self-evaluation tool for ECEC centers. Consequently, the scale exhibits several weaknesses both in terms of how it is organized, which items it includes, and how scores are calculated. For instance, the scales are hierarchically structured in a way that lower-level indicators need to be satisfied in order for higher-level indicators to be included in the scores. However, indicators relating to process quality (e.g., interaction) which are likely the most predictive of child outcomes are often located at the upper-level. Such a scoring procedure arguably lacks theoretical basis in the assumption that 'higher level' quality factors do not matter unless the most 'basic needs' are fully met.

Another open question is whether the scale measures the same thing across the range. Studies finding threshold effects, such as associations between quality (ITERS-R) and cognitive development but only at the upper quality levels (see review by Zaslow et al., 2016) may suggest that the quality construct measures something different in the lower parts of the spectrum. Considering that few of the centers in our sample were scored as high quality, we might therefore not expect quality to have a substantial impact. Furthermore, it is also unclear whether the meaning of the scores are the same across cultural contexts. Do children from different countries respond the same to similar levels of quality? In the absence of such cross-cultural validation, the scales should not be considered standardized in the strict sense that the application of the scales will result in a similar expected outcome. Consequently, standardized assessment tools like ITERS-R which have been developed in an American context may not provide a good measure of quality for children in a Norwegian ECEC system.

4.1.2 Temporality

There may also be other explanations for why we found no relationship between quality and cognitive development that do not relate to the validity of the scale itself but may be a product of having only cross-sectional data. Since children were not assessed prior to ECEC entry (pre-test), we cannot with certainty ascertain whether children experienced a positive change during their time in ECEC up until test age (3 years) since we cannot fully control for whether some children were more likely to attend centers of higher quality than others (selection bias). Although we found that socioeconomic background (i.e. parental education or income level) only marginally predicted center quality level, children were nevertheless not randomly assigned to centers and could differ systematically in unobserved characteristics. Children's cognitive development in relation to ECEC quality therefore had to be inferred from test performance at age 3 years.

Furthermore, we presuppose that quality was stable over time – an assumption that may not be fully tenable. The importance of providing continuity of care for infants and toddlers has been discussed by several (e.g., Horma et al., 2018), and the trajectories of the quality of care provided has been found to be important whether quality is increasing or decreasing over time (Côté, Mongeau, et al., 2013). With only one measured time-point, we can only make assumptions of the stability of quality in the ECEC centers, whether quality increased or decreased over time. The assumption of stability over time can nevertheless be somewhat relaxed if high scoring classrooms are more likely to maintain high scores in general due to mechanisms that are related to them doing well in the first place – and vice versa. The issue of stability over time should however not be conflated with issues relating to ECEC centers under-performing or over-performing the day measurements were taken. Such sources of variation in ECEC quality scores that are attributable to random events do not bias results since the mean of continuous random variables converge in probability on the expected value in accordance with the weak law of large numbers (see Blitzstein & Hwang, 2015). It is nevertheless worth considering the degree to which ECEC centers are qualitatively stable, or whether factors which are likely to affect classroom quality, such as staff-turnover, make them intrinsically unstable in ways that cannot be accounted for without having repeated measurements of quality.

4.2 The importance of entry age for child development

Does entering early cause a change in children's developmental outcomes, or is it merely the case that children who enter early are different from other children and would therefore have developed differently irrespective of their entry age? By leveraging exogenous variation in entry age produced by national uptake regulations we were able to answer this question and quantify the importance of entry age using instrumental variable analysis. It is clear from the comparison of OLS and IV estimates that using traditional covariate adjustment would produce biased results since estimates were inconsistent for at least one cognitive outcome (non-verbal ability), as well as social competence. We attribute these differences in effect estimates to entry age being endogenous, as also suggested by the results from the Wu-Hausman test. The endogeneity in children's entry age is most likely attributable to parents either being able to enroll their children into ECEC regardless of having a legal entitlement, or purposefully delaying enrollment.

In terms of cognitive development, we found a large effect of entry age on children's non-verbal abilities after removing bias using children's birth month as an instrument. Specifically, for every month earlier children enrolled, they performed 14.1% of a standard deviation higher on their non-verbal ability scores at age 3 years ($p < 0.001$). This suggests that Norwegian ECEC centers provide cognitively stimulating environments that children do not readily get at home during the same time period. This runs counter to previous quasi-experimental evidence finding negative effects of entry age – at least for girls – but in ECEC of presumably lower quality (Fort et al., 2016).

However, we did not find that children's verbal abilities were affected by earlier entry into ECEC ($\beta = -0.008$, $p = 0.485$); similar to some previous non-experimental findings (e.g., Barnes & Melhuish, 2017; Côté, Doyle, et al., 2013), but not all (Luijk et al., 2015). Considering the importance of entry age for non-verbal cognition, the lack of effect on children's verbal ability is somewhat surprising. However, there may be several explanations for this. Early language exposure (i.e. speech) has been found to be associated with more rapid vocabulary development and language ability in toddlerhood when it is child-directed, but not when simply overheard (Weisleder & Fernald, 2013); when the interaction is considered to be of high quality (Hirsh-Pasek et al., 2015); and when communication is facilitated in the classroom (Justice, Jiang, & Strasser, 2018). Although the national framework plan places strong emphasis on providing care that is conducive to children's language learning, we had limited ability to test whether the ECEC centers actually met the quality standards necessary to produce beneficial results without good measures of interaction quality. As it stands, this null finding does not provide any evidence that previously reported language benefits of early entry into Norwegian ECEC for children in primary school (Drange & Havnes, 2015) are also present at age 3 years. It should however be taken into consideration that the verbal ability outcome was based on a translated version (from English to Norwegian) of the 'naming vocabulary' assessment with regards to the potential implications for the validity of the measure, as noted in the method section (under 'Cognitive ability'). Since the translated version has not been validated in any sample, we consider the scores derived from the verbal ability assessment to potentially be the most problematic out of the three outcomes (verbal ability, non-verbal ability, and social competence) used throughout Papers I-III.

In terms of the social competence outcome, we found that a standard deviation earlier enrollment resulted in 32% of a standard deviation lower social competence score at age 3 years ($p < 0.01$). Interestingly, this finding therefore runs contrast to the positive effect of early entry for children's non-verbal cognitive ability, as well as a previous non-experimental Norwegian study finding no impact on social competence from increased exposure to ECEC during the early years (Solheim, Wichstrøm, Belsky, & Berg-Nielsen, 2013). However, our estimated causal effect of entry age on social competence was arguably not very large since test score variance was quite small. The standardized effect of 0.32 SD equated to an unstandardized 0.05 lower score for each month earlier enrollment on a 5-point scale. A half-year earlier enrollment would therefore on average only result in a 0.3-point shift in social competence score.

For meaningful interpretation to be made regarding the effects of entry age on either of the three outcomes, we must also consider what the counterfactual mode of care is. Since the counterfactual causal framework is in essence a thought experiment of what would have happened if what did happen had not happened, we need to assess what type of care would plausibly be received under the alternative since the effect of enrolling early is estimated in contrast to the 'control group' (i.e. the children who have not enrolled yet). Are children who do not attend ECEC from age 1 year at home and being taken care of by their parents? According to Drange and Havnes (2015), the most likely alternative to ECEC in Norway for infants and toddlers is parental care at home. We found support for that in our studies, given that 78% of the parents responded that their children had not been cared for by others except for in ECEC. Since effect sizes are not absolute but reflect the magnitude of the effect relative to the alternative mode of care, this also has implications for how results can be generalized to other populations where the counterfactual mode of care may be qualitatively different.

Although we found that entry age does causally influence children's cognitive development (non-verbal) and social competence, it is harder to say why. What is it with early entry that affects children's development? In terms of the negative finding on social competence, it may be the case that the earlier children are enrolled the more likely they are to suffer side-effects of low adjustment periods. In Norway, it is customary for children to spend just a few days adjusting to their new environments accompanied by parents before participating full-time. Not providing sufficient time to adjust could potentially result in negative socio-emotional responses. However, this hypothesis could not be tested since we did not have data on adjustment periods. With regards to the large and positive effects of entry age on non-verbal ability, it may simply be the case that ECEC provides more non-verbal stimulation than parents are able to provide at home. In contrast, parents appear to be good language-users when interacting with their children at home considering that we found no effect of early entry on language development. Thus, with respect to language development, there may be less to gain from early entry into ECEC for children in general, as opposed to disadvantaged children, as has been indicated previously (e.g., Dearing, Zachrisson, Mykletun, & Toppelberg, 2018; Duncan & Sojourner, 2013).

4.2.1 Validity of causal estimates

For causal inference to be valid, some key assumptions (requirements) need to be satisfied – as described under method section (‘**Error! Reference source not found.**‘). One requirement is that the instrument (birth month) needs to be strongly associated with the endogenous predictor (entry age). This was formally tested, and the test results showed that instrument strength was high both in the study of cognitive development ($F = 113.65$), and social competence ($F = 92.69$).

The second assumption relates to how children born in different months of the year, must not differ in observed or unobserved characteristics. If highly educated parents are more prone to time their births than lower educated parents, it could violate this assumption. However, there is some evidence that this assumption does not completely hold in all populations, as Buckles and Hungerman (2013) found that season-of-birth related to maternal characteristics in a sample of American children. We therefore addressed this issue in our IV analyses by including potential confounding variables as covariates in the instrumental variable analyses (see Angrist & Pischke, 2008). However, these had no impact on our causal estimates – indicating that this was not an issue in our sample, adding credibility to the argument of instrument validity.

It is worth noting that causal estimates produced by instrumental variable analyses [IV] are restricted in the sense that they are not valid for all children in the study sample. Because only the portion of variance in entry age that can be predicted from children’s birth month is used to estimate the causal effect, the IV estimator produces a local average treatment affect (LATE) instead of an average treatment effect (ATE). The local average treatment effect is harder to interpret than the average treatment effect, because estimates are only valid for the proportion of children that are affected by their status of eligibility of ECEC enrollment derived from law. This includes 1) children who adhere to the enrollment criterion by enrolling when offer is given (compliers), but excludes 2) children enrolling early without having a legal entitlement to ECEC (always-takers), 3) legally entitled children who are not enrolled when offer of enrollment is given (defiers), 4) and children who are never enrolled (never-takers); 2-4 can jointly be referred to as non-compliers (see Angrist et al., 1996).

4.3 Generalizability

Considering that the selection strategy chosen in the GoBaN / BePro project included centers that were geographically located in relative proximity to universities or university colleges, the sampling procedure did not allow for a completely nationally representative selection. Consequently, this might have some implications for the overall generalizability of the results. As noted in Paper I, the percentage of highly educated parents (university level) in the GoBaN sample was unexpectedly high – approximately twice the population average (Statistics Norway, 2017b). By restricting sampling to only include centers located in urban areas located near universities (see Bjørnestad et al., 2013), the generalizability of the sample is likely to be reduced since urban areas contain a larger proportion of highly educated families (Statistics Norway, 2017b).

It is also important to note that children who had an entry age over age 2 years were not represented in the analyses of the effects of entry age on child outcomes (Papers II-III). This was necessary to secure the validity of the causal design. Since all children have a right to ECEC attendance prior to turning 2 years old, children who were enrolled later than age 2 years were therefore considered to have been withheld voluntarily due to parental choices. These were deemed highly likely to differ in unobserved characteristics compared to other children and would likely bias results as they lay outside the area of validity of our instrument. We also imposed another restriction by excluding children that were not born between February and August. This was done in order to secure a strong instrument. Results may still be valid and generalizable for children born during other parts of the year under the reasonable assumption that children’s birth month is independent of factors that may confound the relationship between their entry age and development (social and cognitive).

4.4 Long-term effects?

Infants and toddlers are an under-researched group, at once being the most impressionable and proportionately growing groups in ECEC. In this dissertation, we have therefore addressed questions relating to infants’ and toddlers’ conditions in ECEC with respect to their social and cognitive development. However, since we were limited by having only cross-sectional data, and short-term (age 3 years) measurements, important questions remain about longer-term outcomes. Longitudinal data (currently being collected by the GoBaN project at age 5 years) would allow for further assessment of the importance of ECEC for school-readiness, by tracking whether the effects reported in this dissertation persist, increase or diminish over time.

The question of whether there are lasting effects of ECEC is somewhat disputed. Despite the general consensus that ECEC is linked to variety of benefits short-term – at least for disadvantaged children – surprisingly many have reported on effects that have tended to fade over time (see Bailey, Duncan, Odgers, & Yu, 2017; W. S. Barnett, 2011; Duncan & Magnuson, 2013). One possible explanation for the fade-out effects is that children from low-income families (i.e. disadvantaged) who have attended programs such as Head Start, often proceed to inferior schools afterwards – effectively undermining positive benefits accrued from ECEC (Lee & Loeb, 1995). This has also explained why the rates of decline have been found to depend on ethnicity, as disadvantaged minorities more often proceed to enroll in schools of lower quality than advantaged groups (Currie & Thomas, 1998). However, in countries like Norway where the economic disparities are less pronounced and most children attend public school after ECEC, there is presumably less heterogeneity in school quality that is linked to socioeconomic background.

Another aspect relating to effects fading out over time is the clear tendency that older American programs (pre-1980) have yielded significantly higher effect sizes than newer American programs. However, as mentioned in the introduction, this can plausibly be attributed to a change in counterfactuals over time since American children today are more likely to be in center-based care (at any quality level) than what was common in previous decades (Duncan & Magnuson, 2013). Despite patterns of effects diminishing over time, some studies have nevertheless found persisting effects in the medium to longer term for high and medium quality (e.g., Hill, Gormley, & Adelstein, 2015; Sylva et al., 2011), and both quality of care and quantity of care have been found to be positively related to cognitive performance in adolescence (age 15) in the NICHD study (Vandell et al., 2010). However, the notion that the impact of ECEC diminishes over time has also been contested. Elango et al. (2015) argue that studies asserting fade-out effects do not account for a diverse set of outcomes, and are frequently restricted to cognitive measures (e.g., IQ). The case for sustained effects of ECEC has been demonstrated economically, at least for disadvantaged children. García, Heckman, Leaf, and Prados (2016) found that every dollar spent on targeted high quality ECEC in the US yielded a 7 dollar return; an annual rate of return equivalent to

13.7% (García et al., 2016) which for most years exceeds returns on stock market investments in the US dating back to the early 1900s (Westervelt, 2016). Furthermore, Heckman (2017) estimated long-term return on investments to be largest when done early, and found declines in returns to be exponential as children aged into adulthood (prenatal programs and early ECEC were the most effective, and later schooling and job-training were the least effective).

The degree to which we should expect long-term effects from universally available ECEC is less clear. In contrast to targeted ECEC programs where children often receive high quality care, the quality that most children experience outside such programs is generally more variable and often not at the level that is expected to be associated with positive developmental outcomes (see Pianta, Barnett, Burchinal, & Thornburg, 2009). Low to medium quality centers may lack in several ways such as having lower teacher-responsiveness and sensitivity in child-interaction – factors which have been found to be important for children's development (Hamre, 2014; Hamre, Hatfield, Pianta, & Jamil, 2013). In a recent Danish study of 30,400 children who had previously been enrolled in universal ECEC were found to have positive long-lasting effects persisting throughout primary school (age 15-16 years); moderated by gender and ethnicity (Bauchmüller, Gørtz, & Rasmussen, 2014). Similarly, a study on children who were enrolled in Norwegian ECEC during a period of rapid expansion and increased governmental subsidies in the 70s showed that children from low-income families benefitted substantially from enrollment, but not for most children of middle or upper-class families (Havnes & Mogstad, 2015).

4.5 Future research and implications

Evaluating the true impact of ECEC is difficult because it is often not possible to separate causation from correlation – a common problem in many areas of research relevant to social policy. Yet, the goal of studying the effects of educational programs such as ECEC is nevertheless to try to gain insight into the mechanics behind the relationships in question in order to advance theory (see Gennetian, Magnuson, & Morris, 2008) – not just study how phenomena co-vary statistically. In two studies (Paper II-III), we therefore focused on causal estimation rather than statistical associations (correlations) using quasi-experimental techniques (instrumental variable analysis). Future studies should consider using similar strategies wherever natural experiments may have been formed from national regulations. In this regard, Papers II-III illustrate a specific use-case in the utility of children's birth month as an exogenous instrument in an instrumental variable framework that enables causal inference. We argue that focusing on causal effects rather than correlations allows for better evaluations of the impact of ECEC on children's development and may further incentivize policy-makers to consider rolling out reforms using random assignment – where possible – which enables causal investigation.

The implications of these current findings are somewhat unclear since we were limited by having short-term outcomes. However, the substantial benefits of early entry on children's non-verbal performance warrant concern over the social implications of today's ECEC uptake regulations given that children who are allowed to start the earliest have a higher chance of gaining a cognitive advantage over children who have to wait, which may increase inequality later in school. Although the right to ECEC has been somewhat extended since this study was conducted – now also entitling children who are born in September, October or November to enroll the month they turn 1 year (Norwegian Ministry of Education and Research, 2017) – it does not entail that all children get to enroll around the same time or age. Furthermore, in today's Norwegian system, families who choose to delay ECEC enrollment are offered a cash-for-care alternative (Norwegian Labour and Welfare Administration, 2017a). Few choose it, but the ones who do are often low-income and immigrant families (Egge-Hoveid, 2014) – which in light of our findings might exacerbate inequalities between advantaged and disadvantaged children due to the delayed enrollment of the children that are most likely to fall behind in school.

However, early entry was not just a benefit since it also decreased social competence at age 3 years. But choosing to postpone enrollment is not ideal. Most parents in Norway have jobs and staying home to tend the children is for most parents likely to be an unfeasible option. The current findings should rather be understood as expressions of how ECEC influences children in both positive and negative ways, in manners which are not likely to be fixed. The inverse effects of entry age on social competence and cognitive development underscore the complexity of how humans develop in relation to their environments. The sheer amount of time children spend in ECEC during their most formative years means that they will have a multitude of experiences – both good and bad (the fact that so many studies nevertheless find weak effects of quality is perhaps indicative of children's own resilience when quality is so often not ideal). In that sense, studies on the effects of ECEC reflect the average net value of attending ECEC for children's development.

Providing children with universal access to ECEC is today an integral part of the Norwegian welfare system, but the economic case for universal ECEC has been argued to be weak (Elango et al., 2015) and that costs may exceed returns for children from upper and middle-class families (Havnes & Mogstad, 2015). However, it could also be argued that long-term future returns cannot be estimated with any accuracy, given the large uncertainties around future economic conditions that may ultimately prove to be more linked with skills that had their foundational beginning in ECEC today than has been the case previously. Economic forecasts are based on previous events, and projections are only valid under the assumption that conditions are held fixed. Perhaps more importantly, it could also be said that providing universal access to ECEC is more about providing a common framework and similar opportunities than an expectation of economic return. ECEC policies should therefore not only be formed on the basis of academic or economic rationales, but also on the societal values that are held to be important. By assessing different aspects of ECEC that may affect children's cognitive and social competence development, this dissertation contextualizes ECEC in a broad life-course perspective, where what happens early in life is likely to be important for later life conditions. By better understanding which factors are beneficial – and detrimental – to children's development, policy-makers and practitioners will be better equipped to provide for children in a way that is best suited to their needs, and set the stage for successful schooling and life in the twenty-first century.

4.6 Conclusion

In conclusion, our studies provide further insight into the complex relationship between ECEC and children's early development by combining both non-experimental and quasi-experimental approaches using a rich set of data. The surprising result that quality was unrelated to cognitive outcomes (verbal and non-verbal) both for advantaged and disadvantaged children could indicate that internationally widely used standardized global quality assessment tools such as ITERS-R may provide little of value in a Norwegian context. Alternatively, the range of quality in Norwegian ECEC may not have been sufficient to demonstrate quality effects on cognitive outcomes.

Although we did not find that ECEC quality predicted child outcomes, we did find that children's age of entry into ECEC was an important causal influence for both social competence and cognitive (non-verbal, but not verbal) development at age 3 years. Causal estimates were obtained by exploiting exogenous variation in children's age of entry into ECEC caused by national ECEC regulations – using children's birth month as an instrumental variable. Interestingly, the findings indicate that there is a trade-off between social competence and cognitive development with regards to whether early entry (< 2 years) is beneficial or not, as a one-month earlier entry resulted in 14.1% of a standard deviation higher non-verbal abilities, while a standard deviation earlier enrollment resulted in 32% of a standard deviation lower social competence at age 3 years.

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Paper I

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.

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 projected, 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

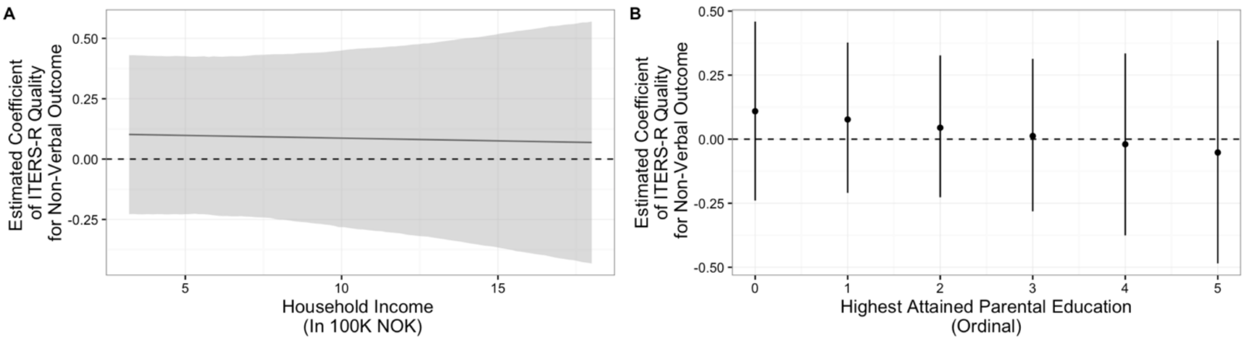

Figure 1. Plots depicting the estimated regression slopes of ECEC quality on children's non-verbal ability at age three years across different family income (A) and education (B) levels. Estimated regression coefficients are shown along the Y-axis, and family background variables along the x-axis. Household 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

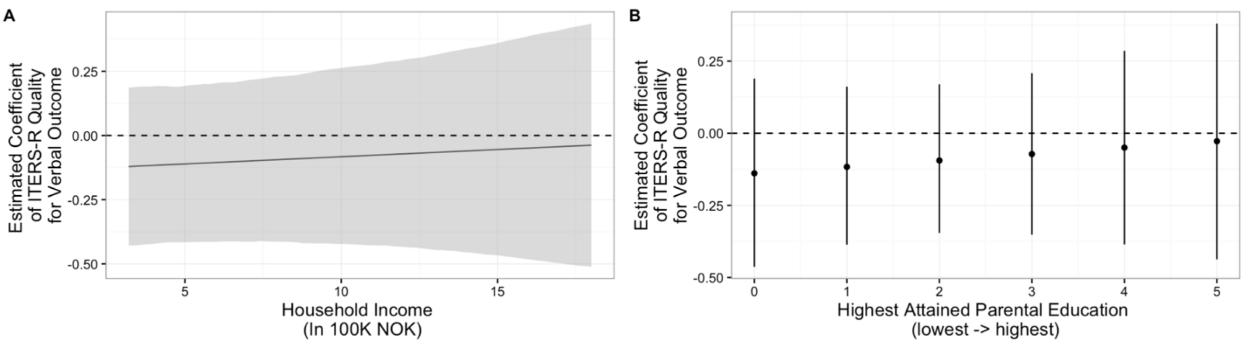

Figure 2. Plots depicting the estimated regression slopes of ECEC quality on children's verbal ability at age three years across different family income (A) and education (B) levels. Estimated regression coefficients are shown along the Y-axis, and family background variables along the x-axis. Household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

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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

Paper II

The Causal Effect of Age of Entry into ECEC on Children's Cognitive Development

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Abstract

By exploiting a 'natural experiment' arising from national regulations in Norway, we estimated the causal effects of children's age of entry into early childhood education and care [ECEC] on short-term cognitive abilities using instrumental variable analysis [IV]. The sample comprised 509 children (primarily from middle-class families) from 87 centers, who entered universal ECEC before age 2 years. The results show that for every month earlier entry, children were predicted an additional 0.141 SD higher non-verbal ability score ($p < 0.001$) after also accounting for within-center quality heterogeneity with group fixed effects. No effect was found for verbal abilities. OLS reference estimates were inconsistent with IV on the non-verbal outcome, suggesting that non-experimental techniques were unable to account for selection bias.

[PAPER UNDER REVIEW AND THEREFORE NOT ATTACHED]

Paper III

The Causal Effect of Age of Entry into ECEC on Children's Social Competence

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Abstract

In many countries providing universal early childhood education and care [ECEC], children are enrolling from an increasingly young age. However, it is unclear how infants and toddlers are affected by the timing of their enrollment. We therefore estimated the causal effect of children's age of entry into ECEC on their social competence at age 3 years by exploiting a 'natural experiment' arising from national ECEC regulations in Norway – using an instrumental variable approach. The sample consisted of 478 children from 81 ECEC centers, who entered ECEC prior to age 2 years. The social competence measure was based on teacher-reports on the Lamer Social Competence in Preschool Scale [LSCIP] and modeled as a latent variable in SEM. The results show that a standard deviation earlier enrollment resulted in 32% of a standard deviation lower social competence at age 3 years ($p < 0.01$). In contrast, we found no effect of age of entry in our non-experimental reference model ($\beta = -0.008$, $p = 0.89$) suggesting that conventional covariate-adjusted estimates may be biased toward zero in similar samples.

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