Running head: Early education and special educational needs

A study of the long-term influence of early childhood education and care (ECEC) on the risk for developing special educational needs (SEN)

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Accepted for publication September 20 2019

Exceptionality Education International

Preschool programs were already viewed in the 1960s as important for preventing or correcting the cognitive deficits found in disadvantaged children (Weikart, 1966 reprinted 2016). For example, the Perry Preschool Project offered a structured preschool program to children identified as in need of special educational services, with mean IQs below 80. After one year of preschool this rose more than 10 IQ points in each of three studies, moving the children out of the range that would define them as having SEN. The program was "an effort to firmly establish the precursors essential for the development of an adequate intellectual foundation to permit the growth of language and logical thought." (Weikart, 2016, p. 11). Weikart concluded the best time to intervene to reduce the risk of special educational needs at school age is between the ages of one and three years.

This paper explores the possible influence of group-based early childhood education and care (ECEC), offered to the general population, on the risk for special educational needs (SEN) drawing from a large-scale longitudinal study in England. The Effective Provision of Pre-school Education (EPPE) project began in 1997, looking initially at the effects of ECEC to age seven (Sylva et al., 2004), then extended to age 11 as the Effective Pre-school and Primary Education project (Sylva et al. 2008), and to age 16 as the Effective Pre-school, Primary and Secondary Education (EPPSE) project (Sylva et al., 2014).

EPPSE has consistently found significant positive effects for ECEC experiences on child outcomes. For instance, attending ECEC compared to none was a significant predictor of higher national examination (General Certificate of Education, GCSE) grades in English and maths and achieving five or more GCSEs at grade range of A-C (Sylva et al., 2014). ECEC quality mattered too, although its effects were weaker than at age 11 (Sylva et al., 2008). Quality significantly predicted English and maths grades, with stronger effects for students whose parents had lower educational qualifications (Sylva a et al., 2014). These

findings suggest that high quality ECEC can narrow the equity gap in achievement between disadvantaged children, possibly at risk for SEN, and those not experiencing disadvantage.

There is growing recognition of the relationship between child social-emotional factors and later outcomes of all types including lower academic scores (Malecki & Elliot, 2002). These earlier behavioral problems also are associated with increased risk of pregnancy, criminal behavior, bullying behaviors and increased substance use in adolescence (Realmuto et al., 2009; Skinner et al., 2015; Verlinden et al., 2015). Looking at social-behavioral development, the EPPSE study found that ECEC influenced outcomes at age 16; high quality was linked to better socio-emotional development including self-regulation, and pro-social behavior (Sammons et al., 2014).

Special education needs have increased in recent decades. Croll and Moses (2003) studied the identification and definition of SEN in England in 1981 and 1998 finding an increase over time from 19% to 26%. With more disadvantage experienced in the population this may rise further. Parsons and Platt (2013) used data from the UK longitudinal Millennium Cohort Study (MCS) to study precursors of SEN. In comparison to children without SEN, more of those with SEN experienced lone parenthood, income poverty and being part of a workless household. In particular, children identified with learning, behavior or speech difficulties experience the most socio-economic disadvantage.

There is abundant evidence of the benefits of ECEC for children generally (e.g., Magnuson, Ruhm & Waldfogel, 2004; Melhuish, 2004; Melhuish et al., 2015). However, little attention has been paid to whether ECEC experience has benefits in relation to the risk of developing SEN. The EPPSE study undertook analyses of the links between ECEC experience and risk of developing SEN in primary school (Early Years Transition and Special Educational Needs (EYTSEN) project; Sammons et al., 2004; Taggart et al., 2006). Children who might be considered as *at risk* of developing SEN by entry to pre-school were monitored

up to the end of Year 1 (age 7). One-third were considered *at risk* at entry to pre-school. By the start of primary school (age 5), this proportion had decreased to 20%. Children who had attended pre-school were significantly less likely to be reported as having any SEN by teachers (25%) than those with no ECEC (40%) (Taggart et al., 2006). When children were ten, teacher's ratings of children's special educational needs were linked to the quality of the ECEC received earlier (Anders et al., 2011). This paper extends that work, looking in greater detail at the risk of SEN across the whole of the compulsory school years (age 5-16 years) and extending the previous work by focusing more on positive aspects of development, particularly well-being.

Self-regulation was used as proxy for well-being, based on the substantial evidence linking it with a range of positive later outcomes in cognitive, social and emotional spheres. Self-regulation shows particularly rapid development between 3-5 years of age (Montroy, Bowles, Skibbe, McClelland & Morrison, 2016). Those children who, by school entry, have a high level are more school-ready, resisting distractions and impulses, delaying gratification, sustaining attention and following rules. However, a minority do not reach the level necessary for school readiness, with consequences that persist (Montroy et al., 2016).

Methodology

Participants

One hundred and forty-one early childhood education and care (ECEC) centers were randomly chosen in six local authorities in England, including all types that existed at the time (1997), including local authority day nurseries, integrated centers with a range of facilities for families, playgroups, private day nurseries, nursery schools and nursery classes. From the 141 ECEC centers, 2857 children were recruited. Those already in centres were recruited when they became three years old; children starting in a centre after their third

birthday were recruited at entry to the ECEC centre. Their mean age at entry to the study was three years five months (SD = 4.6 months), and all had to attend for at least three sessions (session = half-day or 2.5 hours). The distribution of the ECEC sample is shown in Table 1.

Place Table 1 about here

In addition, when children started primary school (age five years) children in the same classes as EPPE children but who had not attended an ECEC centre were recruited to the study as a 'home' (no ECEC) group (n=317). Thus 3,167 children were recruited in total. A comparison of the characteristics of the ECEC sample and home sample is given in Table 2. The home children were considerably more disadvantaged overall, but with sufficient overlap in demographic characteristics to statistically control for demographic differences.

Place Table 2 about here

Measures

Family characteristics and child care use. Semi-structured interviews with parents or guardians were conducted when children entered the study. Follow-up interviews were conducted when children were 6-7 years providing additional data on family characteristics. The interviews covered: parents' education, occupation and employment, family income, family structure, ethnicity, the child's birth weight, health, development and behavior, the use of preschool provision and childcare history.

Home learning environment (HLE). At age three questions covered the frequency of various activities in the home, used to construct the home learning environment (HLE) (Melhuish et al., 2008). Questions covered the frequency of seven activities: going to the library, playing with letters/numbers, painting or drawing, being read to, activities with the alphabet, numbers/shapes and songs/poems/nursery rhymes. These were coded on a 0-7 scale (0=not at all; 7= very frequent) with a total ranging from 0 to 45.

ECEC Centres. Quality was assessed using the Early Childhood Environment Rating Scale – Revised; ECERS-R (Harms et al., 1998) focussing on emotional and social care and the Early Childhood Environment Rating Scale – Extension; the ECERS-E (Sylva et al., 2003), focussing on activities supporting the curriculum (literacy, numeracy, science and diversity). The observational Caregiver Interaction Scale (CIS) was used to assess the quality of staff-child interactions (Arnett, 1989). Overall quality was defined as the mean of the ECERS-R, ECERS-E and CIS.

A continuous measure of ECEC effectiveness was constructed. Children's attainment at the start of primary school (4-5 years) was analyzed in multilevel models controlling for prior attainment at entry to the study (3+years) and background (family and area characteristics). As children were clustered, center-level residuals from the multi-level model provided a measure of the ECEC center's effectiveness. When children performed better than expected at the start of primary school on the basis of initial attainment and background characteristics, the center was more effective; when children performed less well than expected it was considered ineffective.

Child Development.

Special educational need. Special educational need (SEN) was defined by the UK Department for Education and Skill's Code of Practice at the time of the study as follows:

> a) have more significant delay in learning than children of the same age; b) have a disability which prevents or hinders them from making use of educational facilities generally provided for children of the same age in schools within the area of the local education authority; c) are under compulsory school age and fall within the definitions a) or b) above, or would do so if special educational provision was not made for them. (DfES 2001, SEN Code of Practice 2001, p. 6)

However, the application of the code varied between local authorities and between schools within one authority, meaning that a given child might be treated differently depending on which school was attended, and introduced unreliability into the classification of children's needs. To circumvent this, risk of SEN was measured by whether a child was one standard deviation (SD) or more from the mean in the direction of SEN classification. For example, a child scoring one SD or more below the mean on cognitive development would be at risk of learning SEN. Hence, this paper examines the concept of SEN within a framework of potential risk, rather than using the schools' classifications. Aspects of both cognitive and socio-emotional development SEN were addressed.

Cognitive development. The following measures were used to identify those children who were 'at risk' of SEN at four different time points in school from five to 16 years of age, which covers the full range of compulsory schooling in England at the time of the study.

Age 5 years. General cognitive ability (GCA) scores from the British Ability Scales (BAS: Elliot, Smith, & McCulloch, 1996), assessed on a one-to-one basis.

Age 7 years. Key Stage 1 national assessments of literacy and numeracy were used, from a DfE database of all children in the country.

Age 11 years. Key Stage 2 national assessments of literacy and numeracy were used from a DfE database of all children in the country.

Age 16 years. **N**ational assessments (General Certificate in Secondary Education – GCSE) are taken in a range of subjects and recorded in a DfE database. English language results were used as a measure of literacy and mathematics results as a measure of numeracy.

Socio-emotional development. For the purposes of developing measures of risk for SEN in the socio-emotional or social behavioral domain we used teacher reports of externalizing (anti-social) behavior; internalizing (anxious or worried) behavior; and well-being, based on self-regulation. Not all measures were available at all time points.

Age 5 years. Teachers completed an extended version of the Adaptive Social Behavioral Inventory (ASBI; Hogan et al., 1992). Two scores were derived, anti-social/worried/upset behavior and self-regulation (well-being).

Ages 7, 11 and 16 years. Individual children were rated by class teachers on questionnaires that extended the Strengths and Difficulties Questionnaire (Goodman, 1998), providing measures of conduct problems (externalising behaviour), and emotional symptoms (internalising behaviour), with items to enable a measure of self-regulation

Outcome variables

Summary statistics for the outcome variables are given in Table 3. Children were considered to have an SEN risk for a given outcome if their score was more than one sample standard deviation from the sample mean in the direction of poorer outcomes. The cognitive measures were standardized to have mean 100 and standard deviation 15.

Place Table 3 about here.

Two additional outcomes were defined. Children were considered to have a cognitive SEN risk if they had an SEN risk on any of the cognitive measures. Similarly, children were considered to have a socio-emotional SEN risk if they had an SEN risk on any of the socio-emotional measures.

Statistical Analysis

Sample attrition. The original EPPE study included 3,167 children. Some 'lost' at earlier time points have been included in later analyses using their unique pupil identifier in national data sets held by the Department for Education (DfE). The national assessment of educational attainment outcome at age 16 (GCSE) had valid data for 2,582 students (81.5%). The social-behavioral questionnaires from teachers at age 16 were available for 2,401 students (75.8%). Multiple imputation was used to correct for the potential effects of missing data. This includes single items missing for a child and data missing because a child was lost to follow up. Multiple imputation was carried out using the Amelia II package for R (Honaker, King, & Blackwell, 2018). The imputation model assumes a multivariate normal distribution for the complete data, with binary and categorical variables incorporated using appropriate transformations. All outcomes and covariates were included in the multiple imputation model. Ten imputed data sets were generated. Models were fitted to each imputed data set and the results consolidated using Rubin's Rules (Rubin, 1987). The coefficient degrees of freedom were estimated using Hesterberg's (1998) method. In a small number of cases the degrees of freedom estimate for a consolidated coefficient was zero, meaning that a finite confidence interval could not be derived.

Statistical models.

The outcome variables were binary coded as follows: 1 = 'risk of SEN on a given measure', 0 = 'no risk of SEN on this measure'. Models analysed the linear trend across the ECEC usage groups by regressing the outcome on a numeric covariate coded as follows: no ECEC = 0; ECEC, lowest 20% quality/ effectiveness = 1; ECEC, middle 60% quality/ effectiveness = 2; ECEC, highest 20% quality/ effectiveness = 3. The ECEC covariates are summarised in Table 4.

Place Table 4 about here.

Where a significant linear trend was found, further models were fitted comparing the effects of each ECEC quality/ effectiveness group with the no ECEC reference group. Because the data were clustered into ECEC centres, all models were logistic mixed-effects regression models with a random effect for ECEC centre.

Covariates

All models controlled for the following covariates: family day care use (yes / no); relative day care use (yes / no); child's sex; ethnic group; school term of birth; birth weight; family size (number of siblings); child's health problems; child's development problems; maternal age at birth; paternal age at birth; couple / lone parent family; mother's employment status; father's employment status; highest parental qualification; highest parental socio-economic status; family salary and home learning environment index. Continuous covariates are summarised in Table 5 and binary/ categorical covariates in Table 6.

Place Table 5 about here

Place Table 6 about here

Results

Place Table 7 about here

Place Figures 1 to 8 about here

The results of the linear regression models are summarized in Table 7. Because the outcome variables are binary, the model coefficients are odds ratios measuring the change in probability of the child having a given SEN risk factor as one moves from one quality / effectiveness group to the next highest quality / effectiveness group, with no ECEC treated as the lowest quality / effectiveness level.

Cognitive SEN risk

There was a reduced risk of a cognitive SEN at the start of school (age 5) associated with the ECEC effectiveness measure (see Table 7 and Figure 1). Figure 1 shows that this effect is largely associated with the difference between children who have had some ECEC as compared with no ECEC rather than with the difference between more and less effective ECEC. There was a reduced risk of a literacy related SEN at age 11 associated with both ECEC quality and ECEC effectiveness (see Table 7 and Figure 2). At age 16 there were reduced risks of SEN related to both numeracy and literacy associated with both ECEC quality and ECEC effectiveness (see Table 7 and Figures 3 to 4). There was a reduction in the overall risk of children ever having a cognitive SEN associated with both ECEC quality and ECEC effectiveness (see Table 7 and Figure 7).

Socio-emotional SEN risk

The associations between socio-emotional SEN risks and ECEC were less widespread. There was an association between self-regulation problems at age 5 and ECEC quality (see Table 7 and Figure 5). At age 11 there was an association between problems related to externalizing behavior and both ECEC quality and effectiveness (see Table 7 and Figure 6). Finally, there was an association between the overall risk of a child ever having a socio-emotional SEN and ECEC quality, but there was no such association with ECEC effectiveness (see Table 7 and Figure 8).

Discussion and Conclusions

In an observational study such as this it is not possible to establish with certainty that the observed associations between outcomes and covariates are causal. However, the apparent associations between the use of ECEC and also its quality/ effectiveness and subsequent child outcomes could plausibly be explained as causal. The possibility of confounding by

unobserved variables cannot be definitively ruled out. However, a wide range of demographic and parental variables have been controlled for, reducing the risk of confounding considerably. Cautiously, we suggest the existence of a causal association between ECEC use and children's subsequent SEN risks is the most likely explanation for the associations that have been found. A further possible caveat concerns the associations between ECEC effectiveness and children's age 5 general cognitive ability, since the effectiveness measure was defined using children's cognitive outcomes measured at the start of school, creating a risk that the observed association is an artefact of the definition of effectiveness. However, the association between the ECEC effectiveness covariate and children's age 5 GCA is largely due to the difference in outcome between children who have no ECEC and those who have used ECEC (see Figure 1), a contrast which was not part of the definition of ECEC effectiveness. We therefore conclude that this association is unlikely to be an artefact.

The ECEC quality measure was derived from ratings based on direct observation by a researcher, whereas the ECEC effectiveness measure was statistically derived from data collected on child outcomes. Given the difference in methods and forms of data underlying these two measures it might be expected that the patterns of results for prediction of SEN would be rather different. However, there is great similarity in the pattern of results for these two different measures of ECEC "quality" when looking at cognitive aspects of SEN. This is gratifying in that it supports the notion that the results are reflecting real substantive differences in the ECEC experiences of children, and this similarity of results is a form of joint validation for both of the measures. Since effectiveness is based on academic attainment scores it is perhaps not surprising that it was not strongly related to socio-emotional outcomes, but observed quality, which included direct observations of staff-child interactions, could be related to the risk of socio-emotional SEN. The importance of stimulating and supportive interactions in ECEC settings has been highlighted in a number of

studies (Melhuish, et al., 2015) and this study reinforces its relevance in particular for the most vulnerable children.

Overall, the results point towards the provision of high quality ECEC for children significantly decreasing the risk of SEN in later years. Children who had high quality (or effective) ECEC showed a 40-60% lower level of risk for cognitive SEN. The results are not so clear-cut for socio-emotional outcomes but overall the pattern is similar with children who had high quality (or effective) ECEC showing a 10-30% lower risk of developing socio-emotional SEN.

The developmental outcomes of children showing severe and persistent behavioral characteristics of inattention, impulsiveness and hyperactivity (often termed as general behavior "problems" by teachers) may be enhanced by classroom interventions or special teaching methods (DuPaul & Eckert, 1997) or exacerbated by lack of support. However, rather than relying solely on strategies implemented in primary school, it may be more effective to provide high quality pre-school, because children showing higher skills at primary school entry often maintain this advantage at later ages (e.g., Magnuson et al., 2004; Sammons & Smees, 1998; Tymms, Merrell & Henderson, 1997). Promoting better adjustment to school and *school readiness* is a means to help protect children from later being identified as having some form of SEN while they move through primary and secondary school. This study supports the idea, well developed already many decades ago (Weikart, 1966, reprinted 2016) that strategies for supporting groups of children at greater risk of developing SEN during their school career should be provided before they begin primary schooling, to promote resilience.

More specifically we conclude that the targeting of additional resources and professional development to enhancing the quality of preschool provision may be an effective strategy in trying to combat the adverse effects of social disadvantage. This should focus

particularly on preschool settings in the most disadvantaged communities, since previous research has already shown, and the current data also confirm, that more disadvantaged children (those with poor HLE, from low family income and low SES families with parents who have low levels of educational qualifications etc.) are significantly more likely to be identified as showing SEN in primary school. In England the recent policy of introducing Children's Centres in areas of high disadvantage and attempts to raise the quality as well as the availability of preschool in these areas are policy developments that could have long term benefits in helping to reduce the risk of SEN and may help to narrow the attainment 'gap' between advantaged and disadvantaged children (Taggart et al., 2006; Sylva et al., 2008).

In addition to socio-economic disadvantage, the quality of the HLE in the early years and the nature of parent-child interactions are highly predictive for later SEN identification, especially relevant for children with early developmental problems and early health problems, identifiable well before children enter either pre-school or primary school. Studies of successful pre-schools by Siraj-Blatchford et al. (2003) indicate that pre-schools that promote joint activities for parents and children are likely to be especially beneficial for young children. The implications of these findings are that policy makers and practitioners should promote strategies to support improvements in the early years HLE as well as in the quality of pre-school centers. In addition, knowledge of *at risk* factors can be used to help direct resources and programs to target high-risk groups of children and communities, for example through appropriate Children's Center provision.

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Preschool programs were

Table 1. Distribution of the sample members experiencing some early education and care (ECEC) by the type of center

Type of Center	Centers	Number of Children			
	N	N	Mean	SD	Range
Nursery class	25	588	23.52	3.14	13-28
Playgroup	34	609	17.91	4.65	10-28
Private day nursery	31	516	16.65	5.14	6-27
Local authority day care	24	433	18.04	5.01	10-28
Nursery school	20	519	25.95	2.37	19-30
Integrated centre	7	192	27.43	3.55	25-35
Total	141	2857	20.26	5.66	6-35

Table 2. The characteristics of ECEC children compared with home children

		Children with ECEC		Home children (no ECEC)	
		N	**%**	**N**	**%**
Child's sex	Male	1495	52.5	149	47.0
	Female	1355	47.5	168	53.0
Ethnic group	White	2240	78.7	176	55.5
	Black	178	6.3	4	1.3
	Asian	155	5.4	126	39.7
	Mixed / other	274	9.6	11	3.5
Three or more sibs		374	13.4	108	38.7
No parental qualifications		384	13.8	106	39.4
Family salary £2,500 or less		470	21.6	97	48.3

Table 3. Summary statistics for outcome variables

Variable name	Min	Max	Mean	SD	Percent missing	Percent with SEN risk
General cognitive ability (age 5)	60.00	140.00	100.00	15.00	9.1	19.6
Numeracy (age 7)	52.18	137.23	100.00	15.00	15.9	8.3
Literacy (age 7)	60.00	129.45	100.00	15.00	14.2	14.8
Numeracy (age 11)	65.22	135.10	100.00	15.00	14.9	13.6
Literacy (age 11)	45.04	147.05	100.00	15.00	15.2	14.2
Numeracy (age 16)	54.82	135.91	100.00	15.00	17.4	33.2
Literacy (age 16)	49.20	140.24	100.00	15.00	17.1	30.1
Anti-social/worried (age 5)	1.00	4.58	1.74	0.66	9.2	17.9
Self-regulation (age 5)	1.00	5.00	3.50	0.84	9.5	16.4
Externalizing (age 7)	1.00	2.83	1.13	0.24	16.3	9.6
Internalizing (age 7)	1.00	3.00	1.29	0.39	16.3	15.4
Self-regulation (age 7)	1.00	3.00	2.36	0.54	16.4	18.2
Externalizing (age 11)	1.00	2.83	1.11	0.25	16.1	9.6
Internalizing (age 11)	1.00	3.00	1.28	0.39	17.3	14.4
Self-regulation (age 11)	1.00	3.00	2.34	0.48	16.1	16.0
Externalizing (age 16)	1.00	3.00	1.13	0.31	23.5	9.6
Internalizing (age 16)	1.00	3.00	1.31	0.38	23.5	13.6
Self-regulation (age 16)	1.00	3.00	2.22	0.51	23.6	16.5
Cognitive SEN risk					1.2	50.4
Socio-emotional SEN risk					4.0	48.3

Percent of children with SEN risk is calculated as a percentage of those with non-missing data for a given outcome.

Table 4. Summary statistics for ECEC use covariates

	ECEC quality		ECEC effectiveness	
	N	%	N	%
No ECEC	317	10.0	317	10.0
Low	573	18.1	580	18.3
Medium	1715	54.2	1713	54.1
High	562	17.7	557	17.6

Table 5. Summary statistics for continuous covariates

Variable name	Min	Max	Mean	SD	Percent missing
Birth weight (g)	710	6140	3308	622	4.80
HLE index	0.00	45.00	23.11	7.66	5.12

Table 6. Summary statistics for binary and categorical covariates

Variable	Level	N	%
Sex	Male	1644	51.91
	Female	1523	48.09
	Missing	0	0.00
Ethnic group	White	2416	76.29
	Black	182	5.75
	Asian	281	8.87
	Mixed / other	285	9.00
	Missing	3	0.09
Term of birth	Summer (May-Aug)	955	30.15
	Spring (Jan-Apr)	1172	37.01
	Autumn (Sept-Dec)	1039	32.81
	Missing	1	0.03
Number of sibs	No siblings	624	19.70
	1 sibling	1129	35.65
	2 siblings	826	26.08
	3+ siblings	482	15.22
	Missing	106	3.35
Child's health problems	No health problems	2026	63.97
	1 health problem	785	24.79
	2 health problems	213	6.73
	3+ health problems	43	1.36
	Missing	100	3.16
Child's development problems	No developmental problems	2690	84.94
	1 developmental problem	342	10.80
	2+ developmental problems	35	1.11
	Missing	100	3.16
Maternal age	16-20	25	0.79
	21-25	350	11.05
	26-35	1840	58.10
	36-45	805	25.42
	46-65	33	1.04
	Missing	114	3.60

Table 6. (continued)

Variable	Level	N	%
Paternal age*	21-25 / absent father	836	26.40
	26-35	1162	36.69
	36-45	909	28.70
	46-75	139	4.39
	Missing	121	3.82
Lone parent	Couple	2303	72.72
	Lone parent	757	23.90
	Missing	107	3.38
Mother's employment status	Full time	463	14.62
	Part time	890	28.10
	Self-employed	130	4.10
	Not working	1571	49.61
	Missing	113	3.57
Father's employment status*	Full time / absent father	2283	72.09
	Part time	82	2.59
	Self-employed	326	10.29
	Not working	341	10.77
	Missing	135	4.26
Highest parental qualification	None	490	15.47
	Vocational qualification	343	10.83
	Academic (age 16)	1129	35.65
	Academic (age 18)	335	10.58
	Other professional qualification	48	1.52
	Degree or equivalent	483	15.25
	Higher degree	220	6.95
	Missing	119	3.76

* For these covariates, “absent father” was combined with another level in order to avoid collinearity issues with the covariate “lone parent”.

Table 6. (continued)

Variable	Level	N	%
Highest parental SES	Professional	281	8.87
	Intermediate	776	24.50
	Skilled non-manual	973	30.72
	Skilled manual	452	14.27
	Semi-skilled	406	12.82
	Unskilled	79	2.49
	Never worked	88	2.78
	Missing	112	3.54
Family salary	up to £2,500	567	17.90
	> £2,500 up to £15,000	484	15.28
	> £15,000 up to £27,500	411	12.98
	> £27,500 up to £35,000	271	8.56
	> £35,000 up to £66,000	470	14.84
	> £66,000	173	5.46
	Missing	791	24.98
Family day care	No childminder ECEC	2457	77.58
	Childminder ECEC	710	22.42
	Missing	0	0.00
Relative day care	No relative ECEC	2397	75.69
	Relative ECEC	770	24.31
	Missing	0	0.00

Table 7: Results of models of SEN risk outcomes in terms of ECEC covariates.

	Quality of ECEC		Effectiveness of ECEC	
Outcome (age, years)	**Trend**	**95% CI**	**Trend**	**95% CI**
General cognitive ability (age 5)	0.902	(0.727 - 1.120)	0.677 ***	(0.546 - 0.839)
Numeracy (age 7)	0.867	(0.698 - 1.077)	0.911	(0.720 - 1.153)
Literacy (age 7)	0.867	(0.704 - 1.068)	0.897	(0.724 - 1.113)
Numeracy (age 11)	0.866	(0.729 - 1.030)	0.884	(0.736 - 1.062)
Literacy (age 11)	0.739 ***	(0.631 - 0.865)	0.812 *	(0.675 - 0.976)
Numeracy (age 16)	0.836 **	(0.734 - 0.953)	0.836 **	(0.735 - 0.952)
Literacy (age 16)	0.831 *	(0.714 - 0.967)	0.812 **	(0.700 - 0.943)
Anti-social/worried (age 5)	0.950	(0.827 - 1.091)	1.026	(0.886 - 1.190)
Self-regulation (age 5)	0.840 *	(0.713 - 0.989)	0.940	(0.785 - 1.126)
Externalizing (age 7)	0.879	(0.719 - 1.073)	1.050	(0.848 - 1.300)
Internalizing (age 7)	0.923	(0.789 - 1.081)	0.947	(0.811 - 1.106)
Self-regulation (age 7)	0.928	(0.780 - 1.104)	0.978	(0.818 - 1.169)
Externalizing (age 11)	0.788 **	(0.670 - 0.926)	0.827 *	(0.702 - 0.973)
Internalizing (age 11)	0.857	n/a	0.911	(0.775 - 1.071)
Self-regulation (age 11)	0.828	(0.654 - 1.048)	0.892	n/a
Externalizing (age 16)	1.010	(0.820 - 1.244)	0.972	(0.788 - 1.200)
Internalizing (age 16)	0.897	(0.766 - 1.050)	0.958	(0.819 - 1.121)
Self-regulation (age 16)	0.968	(0.823 - 1.138)	0.937	(0.784 - 1.119)
Cognitive SEN risk	0.845 *	(0.728 - 0.980)	0.844 *	(0.731 - 0.974)
Socio-emotional SEN risk	0.872 *	(0.767 - 0.992)	1.044	(0.910 - 1.197)

Statistically significant coefficients are marked with stars: * = p>.05, ** = p>.01, *** = p>.001

CI = Confidence interval

Preschool programs were

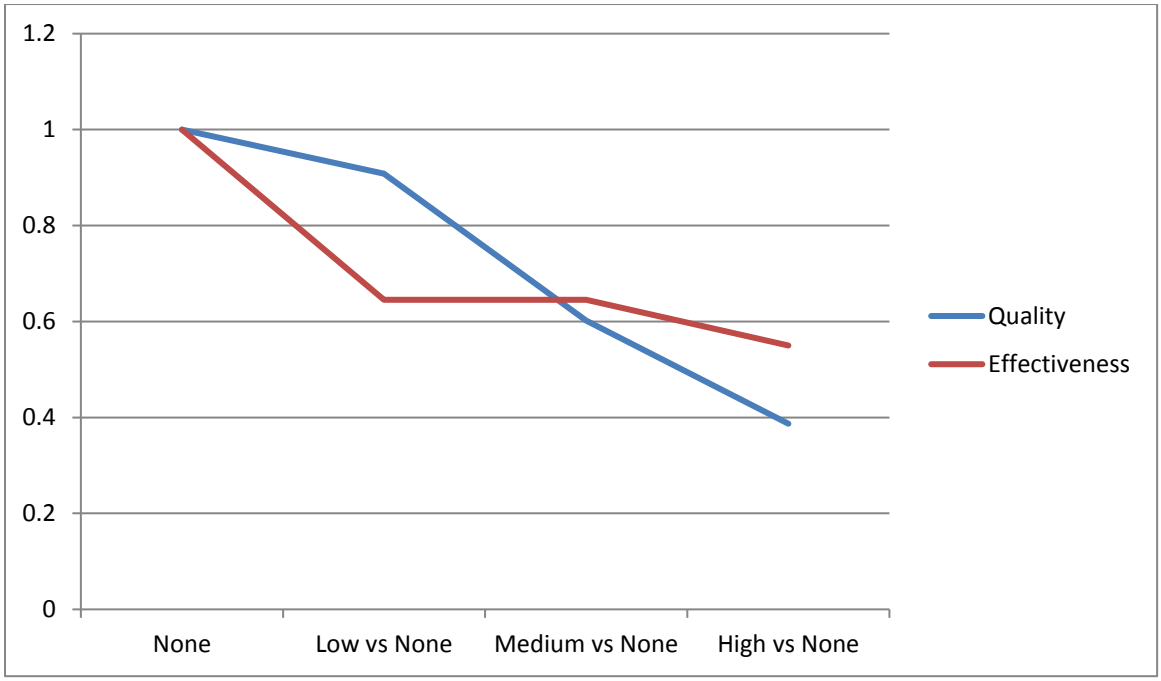

Figure 1: Age five general cognitive ability: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for effectiveness 0.677***

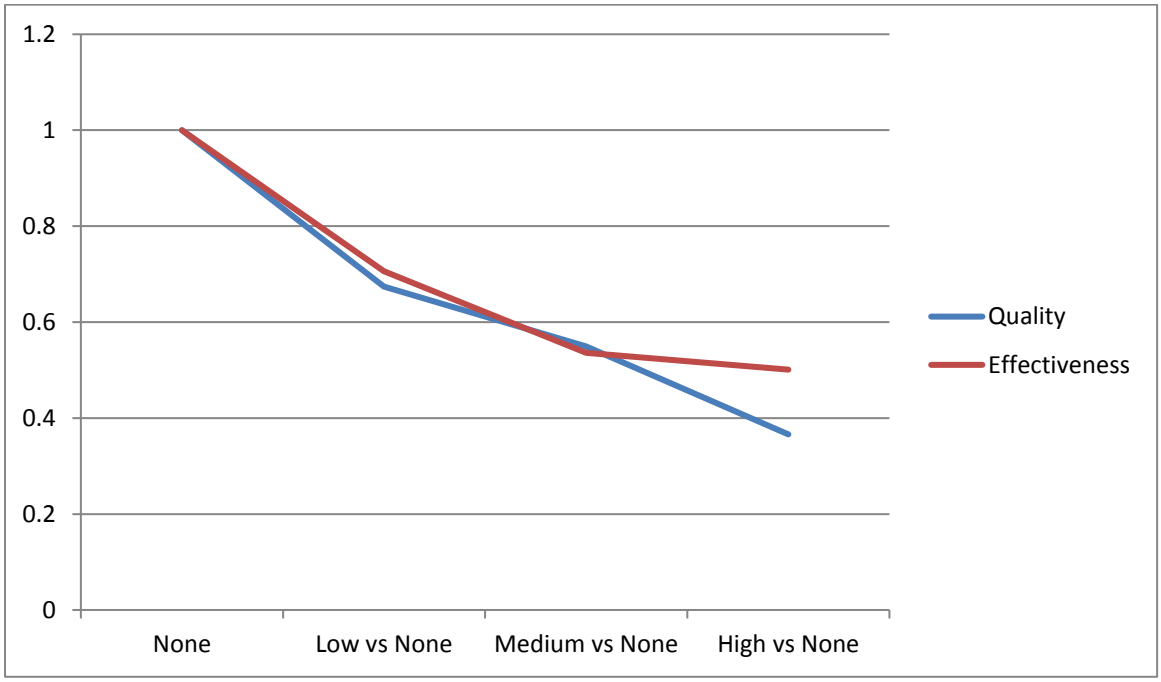

Figure 2: Age 11 literacy: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.739***

Trend significant for effectiveness 0.812*

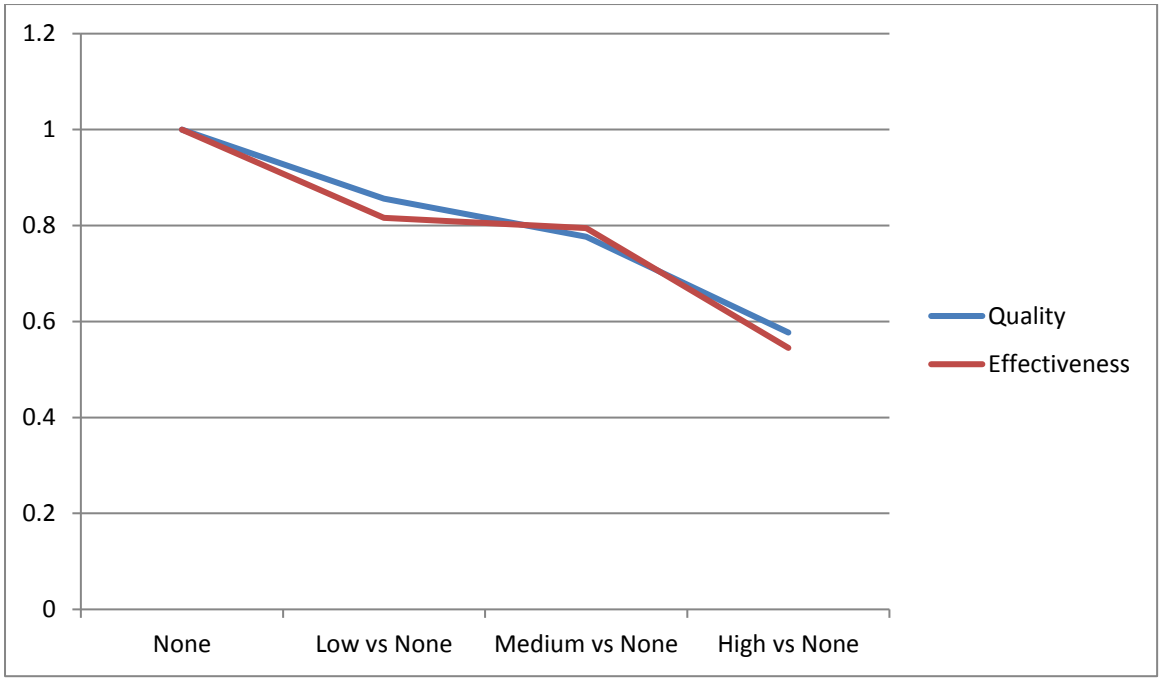

Figure 3: Age 16 numeracy: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.836**

Trend significant for effectiveness 0.836**

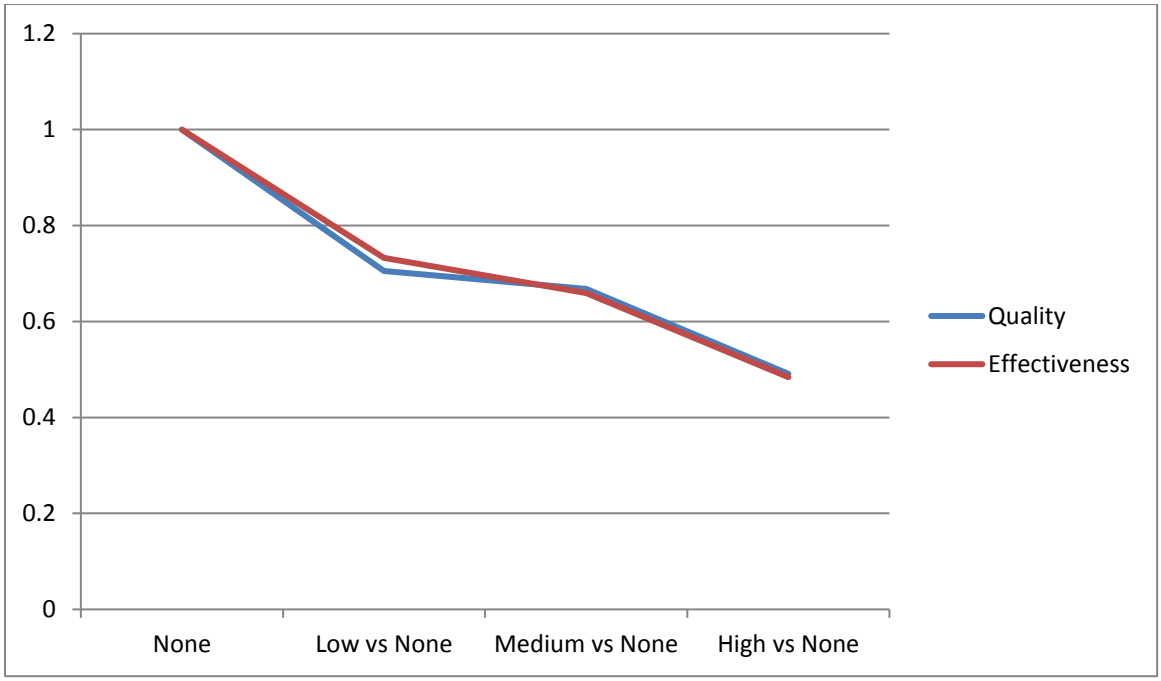

Figure 4: Age 16 literacy: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.831*

Trend significant for effectiveness 0.812**

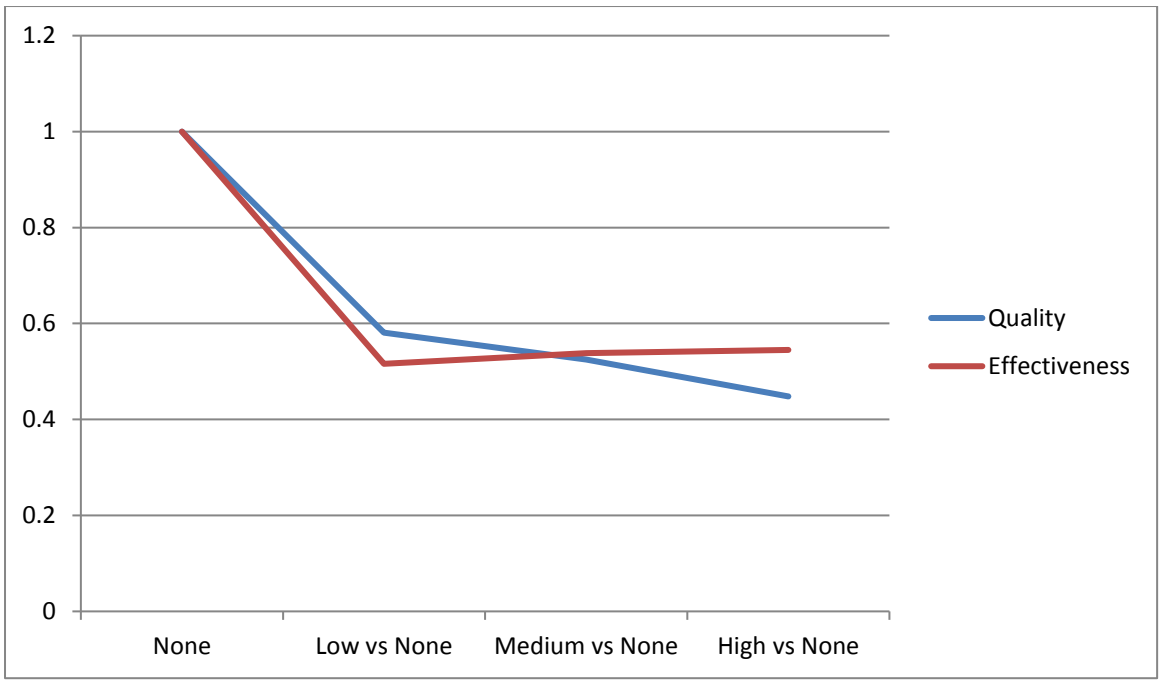

Figure 5: Age five self-regulation (well-being): odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.840*

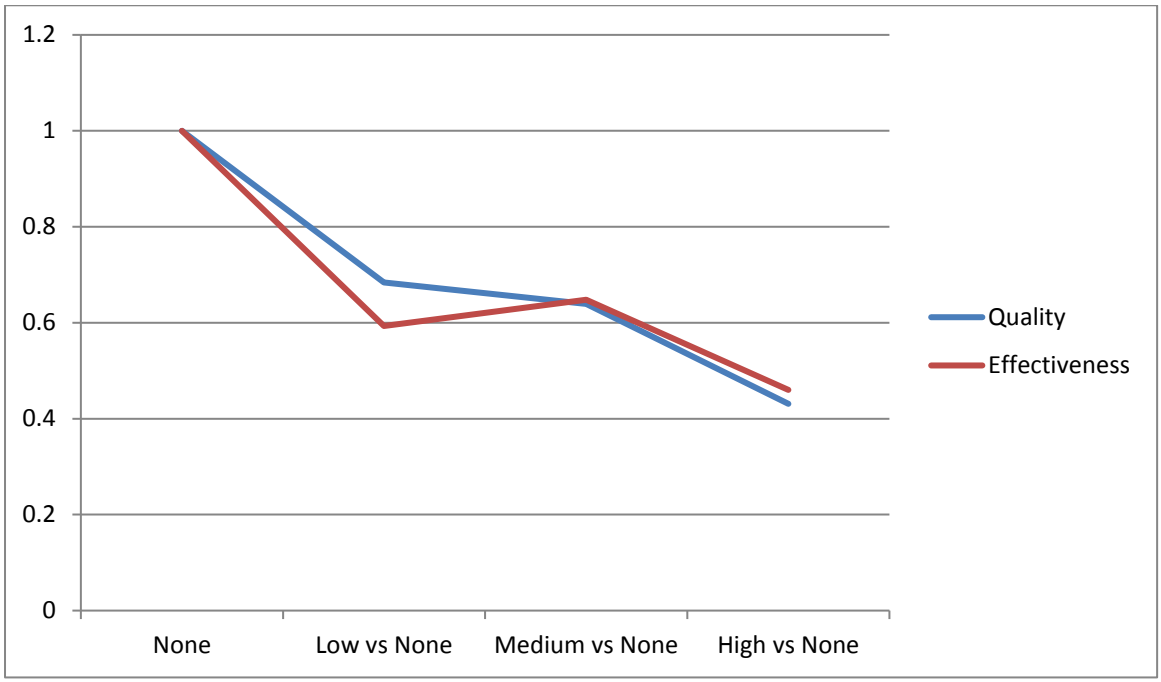

Figure 6. Age 11 externalizing: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.788**

Trend significant for effectiveness 0.827*

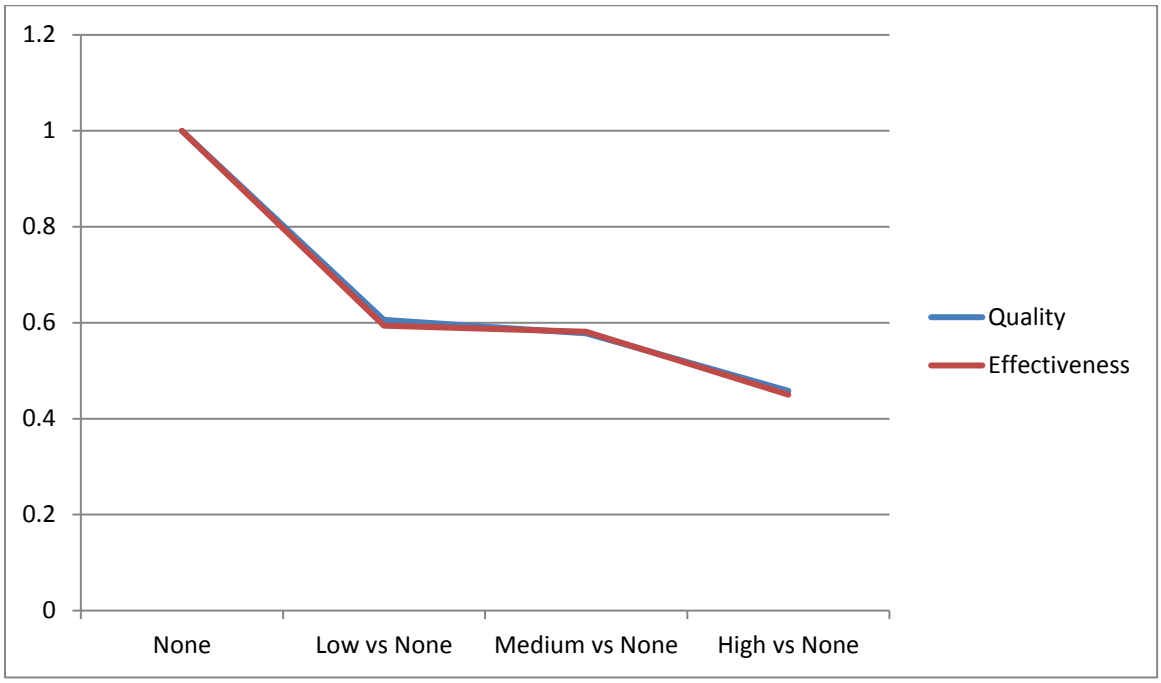

Figure 7. Ever at risk of cognitive SEN: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.845*

Trend significant for effectiveness 0.844**

Preschool programs were

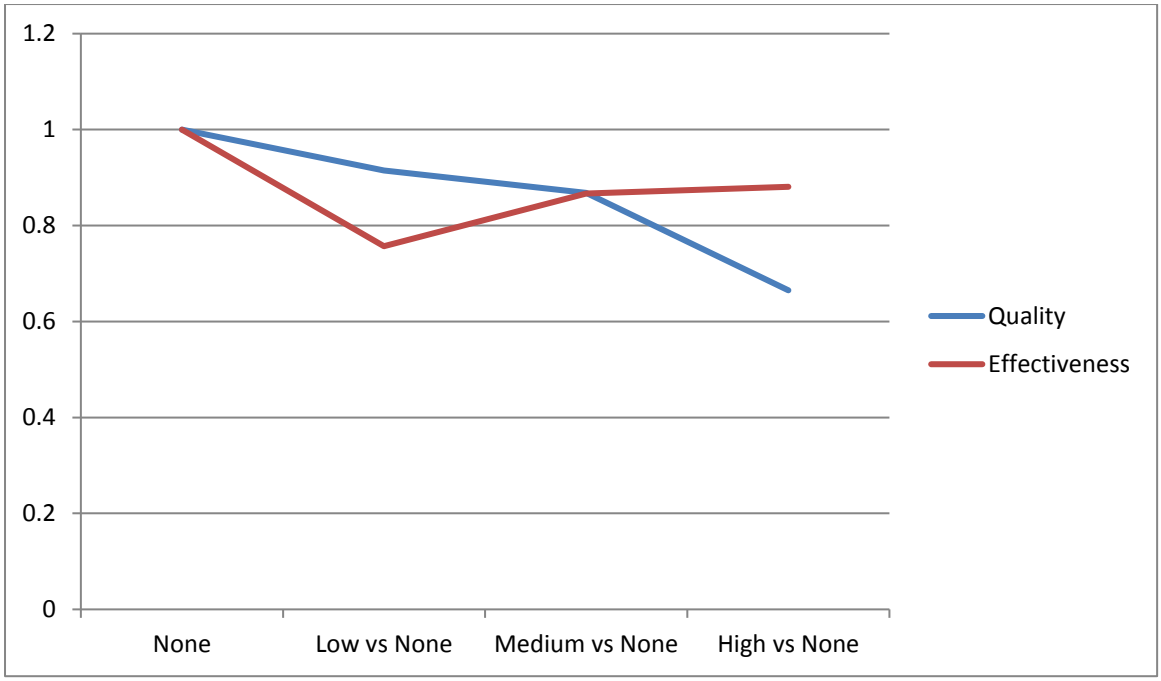

Figure 8. Ever at risk of socio-emotional SEN: odds ratios for risk of SEN: low, medium and high quality and low, medium and high effectiveness ECEC compared with none (lower value = less risk).

Trend significant for quality 0.872*