

Child Care Services, Socioeconomic Inequalities, and Academic Performance

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abstract **OBJECTIVE:** To determine if child-care services (CCS) at a population level can reduce social inequalities in academic performance until early adolescence.

METHODS: A 12-year population-based prospective cohort study of families with a newborn ($n = 1269$). Two CCS variables were estimated: “intensity” (low, moderate, and high number of hours) and “center-based CCS type” (early onset, late onset, and never exposed to center-based CCS).

RESULTS: Children from low socioeconomic status (SES) families who received high-intensity CCS (any type), compared with those who received low-intensity CCS, had significantly better reading (standardized effect size [ES] = 0.37), writing (ES = 0.37), and mathematics (ES = 0.46) scores. Children from low-SES families who received center-based CCS, compared with those who never attended center care, had significantly better reading (ES_{early onset} = 0.68; ES_{late onset} = 0.37), writing (ES_{early onset} = 0.79), and mathematics (ES_{early onset} = 0.66; ES_{late onset} = 0.39) scores. Furthermore, early participation in center-based CCS eliminated the differences between children of low and adequate SES on all 3 examinations (ES = -0.01, 0.13, and -0.02 for reading, writing, and mathematics, respectively). These results were obtained while controlling for a wide range of child and family variables from birth to school entry.

CONCLUSIONS: Child care services (any type) can reduce the social inequalities in academic performance up to early adolescence, while early participation in center-based CCS can eliminate this inequality. CCS use, especially early participation in center-based CCS, should be strongly encouraged for children growing up in a low-SES family.



WHAT'S KNOWN ON THIS SUBJECT: Previous studies indicate that higher quality of child-care services have long-lasting cognitive benefits, regardless of SES. However, there is disparity between studies as to whether child-care intensity and type can reduce these social inequalities up to adolescence.

WHAT THIS STUDY ADDS: At a population level, child-care services were shown to have either reduced or eliminated the social inequalities in academic achievement up to adolescence after careful control of selection bias and attrition.

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Socially disadvantaged children are at high risk for poor academic achievement and school dropout.¹⁻³ The most robust evidence that Child Care Services (CCS) promote academic achievement for these children comes from experimental programs designed to serve the most disadvantaged children.⁴⁻⁶ However, it is not clear whether CCS widely available in communities, which are typically of lower quality than experimental child-care programs, can have comparable effects. Furthermore, large-scale longitudinal studies have shown that, under some circumstances (eg, initiation in infancy), CCS can have a negative impact* on children's cognitive development.⁷⁻⁸ Thus, CCS have tremendous potential for reducing social inequalities, but the conditions under which positive and negative impacts are observed need to be better documented and understood to foster population-wide positive outcomes and avoid iatrogenic effects. A small number of population-based studies have shown that CCS can reduce the socioeconomic disparities in school readiness and school performance at school entry.⁹⁻¹² However, it is unclear to what extent these benefits extend beyond the first few years of primary school and which type and intensity of CCS are needed to achieve these long-term effects. The evidence regarding the short- and medium-term impact of CCS on cognitive outcomes for low socioeconomic status (SES) children is mixed. For instance, a study with a large UK sample ($N = \sim 13\,000$) found that CCS exposure of any type starting in infancy was positively associated with cognitive outcomes for 3-year-old children of low-educated mothers.¹² However, these benefits were not observed at 5 and 7 years. Positive outcomes associated with center-based CCS lasted longer, up to

5 years, but disappeared by 7 years. In 2 Canadian population-based birth cohort studies, the CCS effects on cognitive outcomes for low-SES children were observed at school entry¹⁰ and maintained into grade 1 and 2.¹¹ This suggests that, for socially disadvantaged children, positive CCS contributions can persist into early elementary school years.

A few large-scale longitudinal studies in the United States have shown that the quality of CCS is positively associated with academic achievement up to adolescence.^{9,13-15} However, these studies have not shown specifically that CCS had reduced the socioeconomic inequalities in academic achievement. Also, we do not know which intensity and type of CCS exposure can reduce or eliminate the social inequality gap in the long term. Information on the conditions under which CCS (ie, type and intensity) may serve as a potential equalizer of academic opportunities is necessary to design better CCS.

STUDY OBJECTIVES

The goals of this study were to test (1) whether CCS leads, in the long-term (ie, the end of sixth grade, 12 years), to higher academic achievements for low-SES children relative to adequate-SES children and (2) which intensity and type of CCS exposure are necessary to achieve these long-term benefits. One major challenge in assessing exposure to CCS types is that children typically transition across types during early childhood. To address this issue, we estimated group-based developmental trajectories of CCS "intensity" (ie, number of hours per week) and "type" (ie, center-based vs never center-based CCS). We tested for interactions between SES and CCS trajectories in predicting province-wide school performance examinations (12 years). Close attention was paid to selection bias by controlling for a host of child,

parent, and family confounders across early childhood.

METHODS

Participants

Data from the Quebec Longitudinal Study of Child Development (QLSCD) were used. Through birth registries, the QLSCD selected 2120 singleton newborns representative of the Quebec (Canada) newborns between 1997 and 1998. This study was initiated during the implementation of CCS (family- or center-based settings) offered at low cost (\$5 per day) to families throughout the province. Ethics approval and informed consent were obtained at each data collection year (5 months, 1.5, 2.5, 3.5, 4.5, and 12 years). Full information maximum likelihood (FIML) dealt with missing data when estimating our CCS trajectories and family variables ($N = 2120$). Sample sizes varied thereafter for specific outcomes and predictors. A total of 1077 (reading), 1137 (writing), and 1112 (mathematics) children had Quebec government examination data.¹⁶ To address attrition, 2 sets of multiple imputations were calculated. The first was calculated on our 'full sample', ie, participants with at least one available Quebec government examination score ($n = 1269$). The second is a subsample of the first ($n = 1119$), dropping those who did not receive CCS during the preschool years ($n = 150$).

Measures

Child Care Services

At each assessment, mothers were asked about the number of hours and the type of CCS exposure. The weekly number of hours range from 0, "in parental care" to 60 hours (mode = 40 hours). Analyses comparing exposure to center-based CCS excluded children who remained in parental care during the preschool years ($n = 150$; Table 1). The center-based CCS type variable distinguished (1) center-based CCS (coded as 1),

*Of note, although the term "impact" is used throughout to simplify the text; it does not imply causal effects.

TABLE 1 Descriptive Statistics

	Age	Total (%)	Mean (SD)	Min	Max
Control variables					
Child's gender	5 mo	1269	—	—	—
0 girl	—	597 (47.0)	—	—	—
1 boy	—	672 (53.0)	—	—	—
Child's birth order	5 mo	1269	—	—	—
1, firstborn	—	576 (45.4)	—	—	—
2, had 1 sibling at birth	—	514 (40.5)	—	—	—
3, had 2 siblings at birth	—	132 (10.4)	—	—	—
4, had 3 siblings at birth	—	(2.3)	—	—	—
5, had at least 4 siblings at birth	—	17 (1.3)	—	—	—
Family status	5 mo	1266	—	—	—
0 nonintact	—	244 (19.3)	—	—	—
1 intact	—	1022 (80.5)	—	—	—
SES factor	5–53 mo	1269	—	—	—
0 adequate SES	—	941 (74.1)	—	—	—
1 low SES (bottom 25th quartile)	—	328 (25.9)	—	—	—
CSNR	Birth	1169	0.90 (1.17)	0.00	4.88
Difficult temperament	5 mo	1264	2.72 (1.58)	0.00	8.00
Childbearing age	5 mo	1269	29.00 (5.37)	16.40	44.50
Family dysfunction	5 mo	1257	1.70 (1.40)	0.00	6.55
Neighborhood safety	5 mo	1200	1.81 (0.61)	1.00	3.80
Neighborhood social problems	5 mo	1249	2.79 (0.36)	1.57	3.00
Negative parenting factor	5–53 mo	1269	0.06 (0.62)	–1.54	2.15
Family deviancy factor	5–53 mo	1269	0.01 (0.20)	–0.20	0.71
Parent mental health factor	5–53 mo	1269	0.02 (0.55)	–1.03	1.91
Child peer relationship factor	5–53 mo	1269	–0.02 (0.30)	–1.00	0.55
Independent variables					
CCS intensity	5–53 mo	1269	—	—	—
1 low CCS hours	—	416 (32.8)	—	—	—
2 moderate CCS hours	—	394 (31.0)	—	—	—
3 high CCS hours	—	459 (36.2)	—	—	—
Center-based CCS type	5–53 mo	1119	—	—	—
3 early-onset center-based CCS	—	133 (11.9)	—	—	—
2 late-onset center-based CCS	—	292 (26.1)	—	—	—
1 never center-based CCS	—	694 (62.0)	—	—	—
Dependent variables					
Reading (0 = repeated a grade)	12 y	1075	62.50 (26.44)	0.00	100.00
Writing (0 = repeated a grade)	12 y	1136	65.55 (25.64)	0.00	100.00
Mathematic (0 = repeated a grade)	12 y	1110	65.57 (26.74)	0.00	99.65

The SES factor variable is shown in its categorical formats as used in the analyses. CSNR includes birth weight, gestational age, intrauterine growth retardation, retardation of cranial perimeter growth, congenital abnormalities, Apgar score, and neonatal complications).

provided by mostly trained educators in a nonresidential environment,¹⁶ from (2) “never exposed to center-based CCS,” that is, other CCS types provided by a nonrelative (nanny or family-based CCS) or a relative (ie, grandparent or sibling) in a residential home or in the child’s home (coded as 0).¹⁶

Group-based developmental trajectories were estimated for CCS intensity and center-based type. CCS intensity trajectories were estimated using a nonparametric model for difficult-to-specify data distributions (Kml, R project,¹⁷ published in Herba

et al¹⁸), and the center-based type trajectories were estimated using a semiparametric mixture model (PROC Traj, SAS^{16,19}). The trajectory methods allowed using all early childhood developmental data points (5 months to 4.5 years; FIML; Fig 1). The CCS intensity variable relied on the mean number of hours per week spent in CCS (0 = in parental care), yielding Low-, Moderate-, and High-Intensity trajectories. The center-based type variable estimated the level of exposure to “center-based care” and excluded children who remained in parental care ($n = 150$),

yielding early onset, late onset, and never exposed to center-based CCS trajectories (see Fig 1 notes).

Provincial Government Examinations

Every Quebec student must write Ministry of Education examination at the end of grade 6 (age 12 years). The results of the reading, writing, and mathematics examinations were marked and made accessible by the Quebec’s Institute of Statistic.¹⁶ The scores are percentages and range from 6 to 100. QLSCD participants who did not write these examinations at 12 years because they were previously held back a grade ($n = 97$) were given a score of zero for each examination.¹⁶

Accounting for Selection Bias: Controlling for Confounders

Child, parent, and family characteristics at birth and during the preschool years were considered as potential confounding variables. Unless otherwise indicated, all variables were reported by the mother.

Child Characteristics

The child’s gender (1 = boys), birth order (0 = first born, onward), Cumulative Score for Neonatal Risk (CSNR) and difficult temperament were used in the analyses. The CSNR, created from medical records, is related to other indicators of birth health, including the duration of hospital stay (see Séguin et al²⁰ and Table 1 for further details). The Infancy Difficult Temperament subscale was taken from the Infant Characteristic Questionnaire.²¹

Early Family Environment (5 months)

Childbearing age and family status (1 = intact family; 0 = nonintact, ie, blended or single-parent families) were measured. The 12-item Family Functioning Scale assesses communication, problem resolution, and expression of affect in the family.²² Higher scores reflect family relationship difficulties. Neighborhood perception was

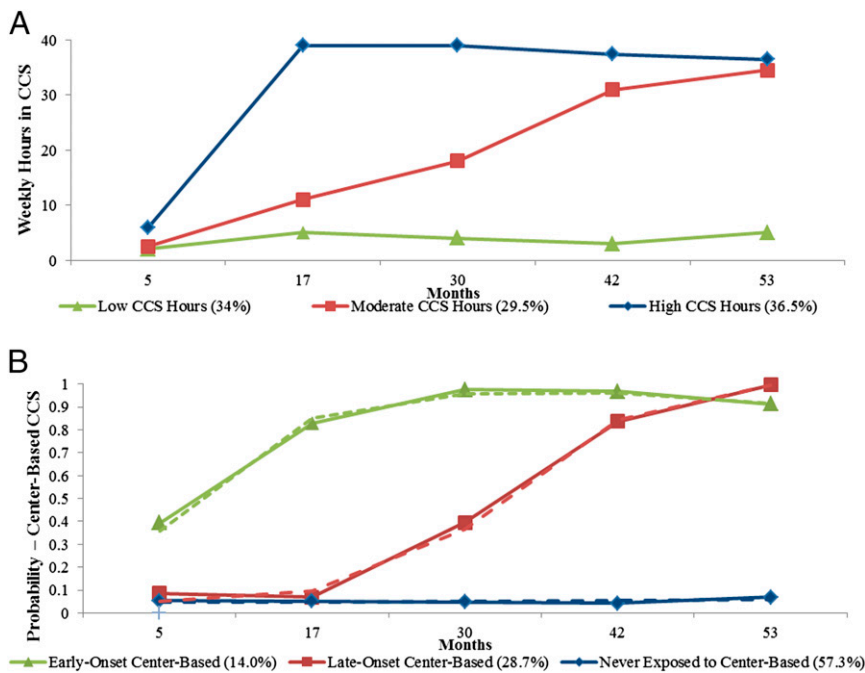


FIGURE 1

Child-care trajectories. A, Intensity ($n = 2120$). The first trajectory is the most common and exhibits a sharp increase in child-care attendance intensity within the first year and remains stable, with high child-care attendance until 4 years (> 35 hours per week); $\sim 36.5\%$ of the children follow the “high-intensity” (number of hours) trajectory. The next trajectory exhibits a gradual increase in child-care hours over the years. Approximately 29.5% of children follow the “moderate intensity” trajectory. The final trajectory is relatively low and stable, with children demonstrating a low number of hours in child-care attendance (< 5 hours per week). An estimated proportion of 34% of the children follow this lowest number of hour trajectory. B, Center-based CCS ($n = 1800$). Solid lines represent observed values. Dashed lines represent predicted values. The first trajectory includes children who have a high probability of attending center-care early (at ~ 1.5 years). Approximately 14% of our sample followed the “early-onset center care” trajectory. In the next trajectory, children have a high probability of being enrolled in other child-care services until 17 months and then gradually increase in their enrollment in center-based care (beginning at ~ 2.5 years). Approximately 28.7% of children followed the “late-onset center care” trajectory. Finally, 57.3% of our sample had a high probability of never being exposed to center-based care during the preschool years (ie, enrolled in other child care services), and this was depicted by the low and stable trajectory.

assessed via 2 variables (0–4).²³ Higher scores on the 7-item neighborhood safety and cohesion measure (eg, “safe to walk alone”) indicate lower safety. Higher scores on the 6-item social problems variable (eg, drug selling in the neighborhood) indicate fewer issues.

Preschool Environment (Birth to 5 Years).

We summarized the information of 108 family variables, collected from both parents from birth to 5 years (438 items),^{16,24} into 6 preschool environmental adversity factors that were created through exploratory and confirmatory factor analyses^{16,24}: (1) SES (ie, parental education, income,

occupational prestige), (2) negative parenting, (3) positive parenting, (4) parent’s deviant behavior (eg, alcohol and drug use, antisocial behaviors), (5) parent’s mental health (eg, depression, anxiety), and (6) child peer relationships (eg, victimization, bullying). SES, considered as the moderator variable, was split at the 25th percentile to form 2 groups (0 = 75% adequate SES; 1 = 25% low SES).

STATISTICAL ANALYSES

Accounting for Attrition

Propensity Score Sample Weights

Propensity score sample weights were calculated to address sample

attrition, with the goal of matching the study sample to the original sample [recruited at 5 months] on demographic characteristics.¹⁶ Weights were calculated as follows. First, the best predictors of missingness on the provincial examination were identified: parents’ education and occupational prestige, family’s income and home stimulation level, frequency of reading to one’s child, and children’s gender. Then each participant was attributed a weight that was inversely proportional to the probability of having a score on the provincial examinations.

Data Imputation

To address data attrition, multiple imputation by chained equations (SPSS) imputed missing values on covariates and outcomes for participants with at least 1 provincial examination score ($n = 1269$). A second imputation was calculated for participants who received CCS ($n = 1119$), excluding the $n = 150$ who remained in parental care. Less than 15% of observations were imputed. We created 100 data sets and conducted regression analyses that pooled results from them.

Confounding Variables

Fifteen potential confounding variables were tested for their bivariate association with academic achievement scores. Those significantly associated with academic achievements were selected as control variables in both regression models (Table 2). Because children of this sample who receive early CCS had different personal and family characteristics than those who did not²⁵ (ie, there was a selection bias of families using the services), we also searched for differences between child-care groups on these 15 variables. Those significantly associated with both child-care participation and academic performance at 12 years were

TABLE 2 Continued

	Center-Based CCS Sample (n = 1119)													
	Dependent Variables: 12-y Government Examinations						Independent Variable: Center-Based CCS Trajectories						Moderator: SES	
	Reading		Writing		Mathematics		Never CB CCS (n = 694)	Late-Onset CB CCS (n = 292)	Early-Onset CB CCS (n = 133)	Adequate (n = 876)	Low (n = 243)	P		
	r	P	r	P	r	P								
Maternal age	0.17	<.001	0.16	<.001	0.12	<.001	28.76 (5.32)	29.26 (5.11)	29.86 (5.60)	29.85 (4.70)	26.03 (6.25)	.06	<.001	
Family dysfunction	-0.07	.03	-0.07	.03	-0.06	.07	1.63 (1.42)	1.69 (1.35)	1.83 (1.37)	1.55 (1.30)	2.10 (1.63)	.20	<.001	
Neighborhood safety	-0.07	.02	-0.10	.003	-0.09	.01	1.79 (0.61)	1.82 (0.61)	1.76 (0.57)	1.76 (0.59)	1.93 (0.65)	.57	<.001	
Social problems in neighborhood	0.09	.003	0.12	<.001	0.12	<.001	2.80 (0.35)	2.78 (0.37)	2.77 (0.35)	2.82 (0.31)	2.67 (0.45)	.56	<.001	
T1—SES factor	-0.28	<.001	-0.27	<.001	-0.28	<.001	0.24 (0.43)	0.20 (0.40)	0.15 (0.36)	—	—	.06	—	
T1—Positive parenting factor	0.03	.34	0.03	.31	0.01	.64	-0.03 (0.35)	-0.08 (0.35)	-0.07 (0.36)	-0.04 (0.35)	-0.08 (0.36)	.11	.12	
T1—Negative parenting factor	-0.08	.01	-0.08	.01	-0.04	.18	0.04 (0.60)	0.14 (0.62)	0.07 (0.64)	0.05 (0.59)	0.13 (0.67)	.04	.08	
T1—Family deviancy factor	-0.06	.09	-0.07	.04	-0.05	.14	0.01 (0.20)	0.01 (0.20)	0.01 (0.20)	-0.01 (0.18)	0.08 (0.25)	.99	<.001	
T1—Parent mental health factor	-0.15	<.001	-0.16	<.001	-0.16	<.001	-0.04 (0.51)	0.09 (0.59)	0.04 (0.62)	-0.09 (0.51)	0.35 (0.56)	.003	<.001	
T1—Child peer relationships factor	0.09	.004	0.10	.002	0.10	.003	0.00 (0.30)	-0.04 (0.31)	-0.05 (0.32)	0.00 (0.30)	-0.08 (0.32)	.07	<.001	

Data are presented as r, mean, and SD. The center-based (CB) CCS sample eliminates those who remained in parental care (n = 150), thus comparing only children who attend CCS. Among the variables tested as potential selection bias factors, only the positive parenting factor was not related to child care, SES, or academic achievement. It was thus dropped from our analyses, leaving 14 confound variables in the analyses. Also, children in either child-care trajectory (independent variables) differed on 1 individual (birth order) and 6 family variables (maternal age, neighborhood safety, social problems in neighborhood, SES, negative parenting, and parental mental health); T1, Time 1, 5 months to 5 years. These 7 selection bias variables were used as controls in the analyses. —, not applicable.

considered a selection bias confounding factor (Table 2).

Modeling Associations Between Each CCS Trajectories and Academic Achievement Scores

Finally, to investigate which CCS intensity and type trajectory best predicted academic achievement scores and whether SES moderated the association, a multiple regression analysis was conducted for each CCS variable. In each model, predictors included (1) child, family, and preschool environment confounders and either the CCS intensity or center-based variable (Step 1) and (2) the interaction between the CCS variable and SES (Step 2). The respective reference groups were “low-intensity” and “never exposed to center-based care” groups. Effect sizes (ES) were calculated by using the following formula: $B(\text{traj}) / SD(Y)$. Values of 0.10, 0.30, and 0.50 represent small, medium, and large ES (standardized coefficient).²⁶

RESULTS

Confounding Variables

The positive parenting factor was unrelated to the academic achievement scores and was dropped from further analyses. A total of 14 confounding variables were included in each model and are shown in Table 2 and 3.

Modeling CCS Trajectories

Both models comprised 3 trajectories of (1) CCS intensity and (2) level of exposure to center-based CCS during preschool. See depiction in Fig 1.

Modeling Associations Between CCS Trajectories and Academic Achievement Scores

Table 3 presents the results of the 2 sets of multiple regressions. Because results for complete and imputed data were equivalent,¹⁶ only the latter is reported. The model with CCS intensity trajectories distinguished participants’ reading, writing, and

TABLE 3 Child Care Trajectories (Intensity and Center-Care) Predicting Preadolescent Academic Achievement Scores Using Multiple Linear Regressions

	Reading				Writing				Mathematics			
	B	95% CI	P	ES	B	95% CI	P	ES	B	95% CI	P	ES
Model with CCS intensity (n = 1269)												
Step 1												
Gender	-8.53	-11.42 to -5.64	<.001	-0.34	-11.73	-14.43 to -9.03	<.001	-0.47	-4.78	-7.73 to -1.84	.001	-0.18
Birth order	-1.91	-3.84 to 0.01	.05	-0.08	-2.42	-4.22 to -0.62	.008	-0.10	-2.05	-4.00 to 0.10	.04	-0.08
Family status	4.82	1.02 to 8.63	.01	0.19	4.58	0.97 to 8.19	.01	0.19	6.53	2.57 to 10.50	.001	0.25
CSNR	-0.97	-2.52 to 0.58	.22	-0.04	-0.73	-2.19 to 0.73	.33	-0.03	-0.68	-2.28 to 0.92	.40	-0.03
Difficult temperament	1.91	0.45 to 3.36	.01	0.08	1.93	0.56 to 3.31	.006	0.08	1.60	0.11 to 3.09	.04	0.06
Maternal age	2.14	0.56 to 3.73	.008	0.08	1.62	0.13 to 3.11	.03	0.07	1.11	-0.55 to 2.76	.19	0.04
Family dysfunction	-0.46	-2.16 to 1.23	.59	-0.02	-0.37	-1.94 to 1.20	.64	-0.02	0.09	-1.60 to 1.78	.92	0.00
Neighborhood safety	-0.26	-1.86 to 1.34	.75	-0.01	-0.65	-2.11 to 0.82	.39	-0.03	-0.81	-2.42 to 0.80	.32	-0.03
Social problems in neighborhood	-0.11	-1.77 to 1.54	.90	0.00	0.28	-1.26 to 1.82	.72	0.01	0.23	-1.42 to 1.87	.79	0.01
T1—SES factor	-15.32	-19.19 to -11.45	<.001	-0.60	-14.68	-18.28 to -11.08	<.001	-0.59	-14.13	-18.06 to -10.20	<.001	-0.54
T1—Negative parenting factor	-0.54	-2.56 to 1.48	.60	-0.02	-0.2	-2.08 to 1.67	.83	-0.01	0.39	-1.66 to 2.45	.71	0.02
T1—Family deviancy factor	0.68	-1.05 to 2.40	.44	0.03	0.32	-1.28 to 1.92	.70	0.01	0.87	-0.85 to 2.59	.32	0.03
T1—Parent mental health factor	-0.91	-3.18 to 1.36	.43	-0.03	-0.92	-3.01 to 1.17	.39	-0.04	-0.97	3.23 to 1.29	.40	-0.04
T1—Child peer relationships factor	0.44	-1.52 to 2.39	.66	0.02	0.32	-1.49 to 2.14	.73	0.01	1.49	-0.47 to 3.45	.14	0.06
CCS intensity trajectory contrasts												
High vs low CCS hours	-0.28	-3.97 to 3.42	.88	-0.01	2.67	-0.79 to 6.13	.13	0.10	1.06	-2.62 to 4.73	.57	0.05
Moderate vs low CCS hours	-1.81	-5.47 to 1.85	.33	-0.07	0.09	-3.27 to 3.45	.96	0.00	-0.76	-4.42 to 2.89	.68	-0.03
Step 2												
SES interactions with CCS intensity trajectory contrasts												
High vs low intensity × SES	9.49	0.06 to 18.92	.05	.37	9.15	0.25 to 18.05	.04	0.37	11.81	2.23 to 21.38	.02	0.46
Moderate vs low intensity × SES	4.00	-3.60 to 11.60	.30	.16	5.78	-1.35 to 12.91	.11	0.24	2.57	-5.26 to 10.40	.52	0.10
R ²	0.154	—	<.001	—	0.189	—	<.001	—	0.128	—	<.001	—
F	14.21	—	<.001	—	18.26	—	<.001	—	11.53	—	<.001	—
Δ R ²	0.003	—	.12	—	0.004	—	.08	—	0.005	—	.05	—
Δ F	2.408	—	—	—	2.837	—	—	—	3.407	—	—	—
Model with CB CCS type (n = 1119)												
Step 1												
Gender	-8.78	-11.82 to -5.73	<.001	-0.34	-11.67	-14.51 to -8.83	<.001	-0.46	-4.80	-7.82 to -1.78	0.002	-0.18
Birth order	-1.59	-3.65 to 0.46	0.13	-0.06	-2.64	-4.54 to 0.73	0.007	-0.10	-1.90	-3.95 to 0.14	0.07	-0.07
Family status	4.32	0.14 to 8.51	.004	0.17	3.70	-0.23 to 7.63	0.07	0.15	6.60	2.36 to 10.85	0.002	0.26
CSNR	-0.68	-2.33 to 0.97	.42	-0.03	-0.37	-1.93 to 1.19	.64	-0.01	-0.37	-2.05 to 1.31	0.67	-0.01
Difficult temperament	2.21	0.68 to 3.73	0.004	0.09	2.03	0.62 to 3.44	0.005	0.08	1.82	0.28 to 3.36	0.02	0.07
Maternal age	2.62	0.90 to 4.33	0.003	0.10	2.38	0.79 to 3.98	0.003	0.09	1.30	-0.41 to 3.01	0.13	0.05
Family dysfunction	-0.25	-2.02 to 1.52	0.78	-0.01	-0.13	-1.82 to 1.55	0.88	0.00	0.53	-1.24 to 2.30	0.56	0.02
Neighborhood safety	-0.39	-2.07 to 1.29	0.65	-0.02	-0.75	-2.31 to 0.82	0.35	-0.03	-0.77	-2.47 to 0.92	0.37	-0.03
Social problems in neighborhood	0.51	-1.23 to 2.25	0.57	0.02	1.27	-0.38 to 2.93	0.13	0.05	1.07	-0.71 to 2.84	0.24	0.04
T1—SES factor	-13.92	-18.10 to -9.73	<.001	-0.54	-13.33	-17.25 to -9.42	<.001	-0.54	-13.59	-17.87 to -9.31	<.001	-0.53
T1—Negative parenting factor	-0.66	-2.75 to 1.42	0.53	-0.03	-0.43	-2.43 to 1.57	0.67	-0.02	0.54	-1.58 to 2.66	0.62	0.02
T1—Family deviancy factor	0.61	-1.22 to 2.43	0.62	0.03	0.41	-1.23 to 2.05	0.82	0.02	0.89	-0.87 to 2.65	0.32	0.03
T1—Parent mental health factor	-0.69	-3.07 to 1.68	0.57	-0.03	-0.79	-3.01 to 1.42	0.48	-0.03	-1.33	-3.70 to 1.04	0.27	-0.05
T1—Child peer relationships factor	0.19	-1.88 to 2.27	0.85	0.01	-0.05	-1.99 to 1.89	0.96	0.00	0.79	-1.28 to 2.87	0.46	0.03

TABLE 3 Continued

	Reading			Writing			Mathematics			
	B	95% CI	P	B	95% CI	P	B	95% CI	P	ES
OB CCS trajectory contrasts										
Early-onset vs never	-3.19	-7.91 to 1.53	0.19	-0.49	-4.95 to 3.97	0.83	0.45	-4.34 to 5.24	0.85	0.02
Late-onset vs never	-2.02	-5.57 to 1.53	0.27	-0.95	-4.23 to 2.32	0.57	-1.70	-5.24 to 1.83	0.35	-0.07
Step 2										
SES interactions with OB CCS trajectory contrasts										
Early-onset vs never × SES	17.42	5.10 to 29.74	0.006	19.71	7.77 to 31.64	0.001	16.18	2.22 to 30.13	0.02	0.66
Late-onset vs never × SES	9.21	0.66 to 17.76	0.03	5.94	-2.22 to 14.10	0.15	9.82	0.97 to 18.68	0.03	0.39
R ²	0.140	—	<.001	0.164	—	<.001	0.118	—	<.001	—
F	11.18	—	<.001	13.56	—	<.001	9.22	—	<.001	—
Δ R ²	0.009	—	0.006	0.009	—	0.003	0.006	—	0.01	—
Δ F	5.581	—	—	6.063	—	—	3.038	—	—	—

ES are standardized coefficients. Gender: 1 = boys, 0 = girls; birth order: 0 = firstborn, 1 = has siblings; family status: 1 = intact family, 0 = nonintact (blended or single-parent families); SES: 0 = adequate (top 75th quartile), 1 = nonadequate (bottom quartile). —, not applicable; CI, confidence interval; T1, Time 1, 5 months to 5 years.

mathematic academic achievement score at 12 years (Table 3). There was a significant interaction between SES and CCS intensity, indicating that low-SES children who received high-intensity CCS (any type) had moderately better reading and writing scores (both ES = 0.37), and largely higher scores in mathematics (ES = 0.46) than low-SES children who received moderate- or low-intensity CCS (Fig 2a).

The second model with center-based CCS trajectories also distinguished children's reading, writing, and mathematics scores and focused on the potential benefit for children who were exposed to center-based CCS versus those never exposed to it (Table 3). Both interaction terms of SES and center-based CCS (ie, SES × early-onset center and SES × late-onset center) were significant for reading and mathematics, whereas only early-onset was significant for writing (Fig 2b). These results suggest that exposure to early-onset center-based CCS for low-SES children is associated with large gains in reading, writing, and mathematics scores (respective ES: 0.68, 0.79, 0.66), whereas late-onset center-based CCS is associated with moderately better reading and mathematics scores (respective ES: 0.37, 0.39).

Supplemental Analysis

We decomposed the CCS interactions by assessing SES “within effects” on each level of the trajectories. Akin to an analysis of variance (generalized linear model), the 3 interaction terms shown in Table 4 indicate whether there are significant mean differences remaining between children of different socioeconomic background within each trajectory level. Whereas high-intensity CCS completely eliminated the SES gap in mathematics (ES: -0.20), only early-onset exposure to center care did so in every discipline (respective reading, writing, and mathematics ES: 0.00, 0.13, -0.02).

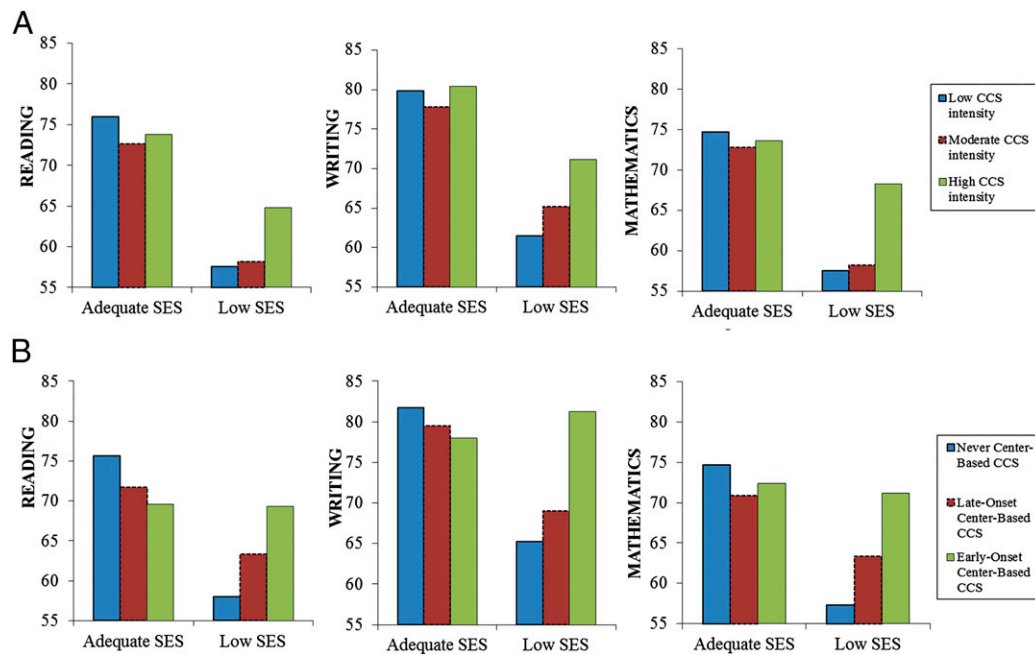


FIGURE 2

Interaction between CCS trajectories and SES on reading, writing, and mathematics academic achievement scores. A, Intensity. B, Center-based CCS. Confounding variables in each model includes the child's gender and temperament, birth order, and Cumulative Score for Neonatal Risk (includes birth weight, gestational age, intrauterine growth retardation, retardation of cranial perimeter growth, congenital abnormalities, Apgar score, and neonatal complications), maternal childbearing age, family status and functioning, neighborhood safety and social problems, and 5 of the preschool environment factors (SES, negative parenting, family deviancy, mental health, child peer relationships).

We also undertook supplemental analyses in which we controlled for children's cognitive assessments at 7 years, maternal IQ, and the level of stimulation in the child's home environment (Home Observation for Measurement of the Environment Inventory Short-Form; Verbalization and Stimulation subscales²⁷) to examine whether associations between CCS intensity or type and achievement at 12 years could be explained by these factors. Controlling for either did not alter associations of CCS intensity and center-based type with academic achievements.¹⁶

DISCUSSION

We examined the long-term associations between CCS during early childhood and academic achievement in early adolescence, with a specific focus on the educational benefits of CCS for low SES youth. Results revealed that for low-SES children, exposure to CCS

(any type) >35 hours a week was associated with better academic achievement in all disciplines (reading, writing, and mathematics) at 12 years. We also found that low-SES children exposed to center-based CCS earlier in life (ie, from 5 months) had better reading, writing, and mathematics scores than low-SES children never exposed to center-based CCS, whereas those exposed to center-based CCS later (ie, from 1.5 years) only had better reading and mathematics scores. These results were obtained while accounting for selection bias into CCS over the first 5 years of life, attrition, and missing data.

ES analyses revealed that when low-SES children received intensive CCS (>35 hours a week), academic achievements were moderately (reading, writing) to largely (mathematics) improved. Similarly, when low-SES children receive center-based CCS later (ie, from 1.5 years), their scores were moderately

improved. Importantly, when low-SES children received center-based CCS early (ie, from 5 months), the gains were large enough to perform at the same level as children from higher SES.

We found that CCS were not associated with academic achievement for children who were from an adequate-SES family (75% of the sample), which is consistent with previous results with this sample.^{10,11} Together, the results support the notion that for children who are growing up in an adequate-SES family environments, CCS do not make a significant difference, positive or negative, on their long-term academic performance. However, for children from low-SES background, CCS (in general and center-based CCS in particular) promote higher academic performance.

It is important to note that in the current study, CCS that were not center based were mainly family based (varying from 10%–30% from

TABLE 4 SES Within Effects for Child-Care Trajectories (Intensity and CB Type): Predicting SES Differences in Preadolescent Academic Achievement Scores Using Multiple Linear Regressions

	Reading				Writing				Math			
	B	95% CI	P	ES	B	95% CI	P	ES	B	95% CI	P	ES
	Model with CCS intensity (n = 1269)											
Gender	-8.52	-11.41 to -5.63	.00	-0.34	-11.72	-14.42 to -9.03	.00	-0.47	-4.77	-7.71 to -1.83	.00	-0.18
Birth order	-1.92	-3.85 to 0.00	.05	-0.08	-2.42	-4.22 to -0.62	.01	-0.10	-2.08	-4.02 to -0.13	.04	-0.08
Family status	4.89	1.09 to 8.69	.01	0.19	4.63	1.03 to 8.24	.01	0.19	6.63	2.67 to 10.59	.00	0.25
CSNR	-1.03	-2.59 to 0.53	.19	-0.04	-0.77	-2.23 to 0.69	.30	-0.03	-0.78	-2.38 to 0.82	.34	-0.03
Difficult temperament	1.91	0.45 to 3.36	.01	0.08	1.94	0.57 to 3.32	.01	0.08	1.59	0.10 to 3.08	.04	0.06
Maternal age	2.17	0.58 to 3.76	.01	0.08	1.63	0.15 to 3.12	.03	0.07	1.15	-0.50 to 2.80	.17	0.05
Family dysfunction	-0.49	-2.18 to 1.20	.57	-0.02	-0.38	-1.95 to 1.19	.64	-0.02	0.04	-1.65 to 1.73	.96	0.00
Neighborhood safety	-0.18	-1.78 to 1.42	.82	0.00	-0.58	-2.04 to 0.88	.44	-0.02	-0.71	-2.32 to 0.91	.39	-0.03
Social problems in neighborhood	-0.16	-1.81 to 1.50	.85	0.00	0.22	-1.32 to 1.76	.78	0.01	0.19	-1.46 to 1.84	.82	0.01
T1—Negative parenting factor	-0.60	-2.62 to 1.42	.56	-0.02	-0.26	-2.14 to 1.61	.78	-0.01	0.33	-1.72 to 2.39	.75	0.01
T1—Family deviancy factor	0.58	-1.15 to 2.31	.51	0.02	0.23	-1.37 to 1.83	.78	0.01	0.74	-0.98 to 2.47	.40	0.03
T1—Parent mental health factor	-0.93	-3.20 to 1.34	.42	-0.04	-0.95	-3.04 to 1.14	.37	-0.04	-0.98	-3.24 to 1.28	.40	-0.04
T1—Child peer relationships factor	0.42	-1.53 to 2.38	.67	0.02	0.33	-1.48 to 2.15	.72	0.01	1.45	-0.51 to 3.41	.15	0.05
CCS intensity trajectory contrasts												
High vs low CCS hours	-2.23	-6.39 to 1.93	.29	-0.09	0.56	-3.36 to 4.49	.78	0.02	-1.10	-5.29 to 3.09	.61	-0.04
Moderate vs low CCS hours	-3.37	-7.83 to 1.10	.14	-0.13	-2.03	-6.16 to 2.10	.33	-0.09	-1.93	-6.37 to 2.51	.39	-0.07
SES interactions with CCS intensity trajectories												
High CCS intensity × SES	-8.94	-17.25 to 0.63	.03	-0.35	-9.22	-17.01 to -1.42	.02	-0.37	-5.33	-13.60 to 2.94	.21	-0.20
Moderate CCS intensity × SES	-14.43	-20.38 to -8.47	.00	-0.56	-12.59	-18.16 to -7.02	.00	-0.50	-14.57	-20.73 to -8.41	.00	-0.56
Low CCS intensity × SES	-18.43	-23.75 to -13.11	.00	-0.72	-18.37	-23.35 to -13.39	.00	-0.74	-17.14	-22.58 to -11.69	.00	-0.66
R ²	0.16	—	—	—	0.19	—	—	—	0.13	—	—	—
F	12.93	—	<.001	—	16.60	—	<.001	—	10.67	—	<.001	—
Model with CB CCS type (n = 1119)												
Gender	-8.73	-11.76 to -5.69	.00	-0.33	-11.63	-14.46 to -8.80	.00	-0.46	-4.75	-7.76 to -1.74	.00	-0.18
Birth order	-1.73	-3.79 to 0.32	.10	-0.07	-2.85	-4.75 to -0.94	.00	-0.11	-2.02	-4.07 to 0.02	.05	-0.08
Family status	4.34	0.17 to 8.51	.04	0.17	3.76	-0.16 to 7.68	.06	0.15	6.61	2.38 to 10.84	.00	0.26
CSNR	-0.68	-2.32 to 0.97	.42	-0.03	-0.34	-1.89 to 1.21	.67	-0.01	-0.37	-2.05 to 1.30	.66	-0.01
Difficult temperament	2.38	0.86 to 3.90	.00	0.09	2.15	0.73 to 3.56	.00	0.09	2.00	0.46 to 3.54	.01	0.08
Maternal age	2.59	0.87 to 4.30	.00	0.10	2.42	0.83 to 4.01	.00	0.09	1.26	-0.45 to 2.97	.15	0.05
Family dysfunction	-0.34	-2.10 to 1.42	.70	-0.01	-0.21	-1.89 to 1.47	.81	-0.01	0.43	-1.33 to 2.19	.63	0.01
Neighborhood safety	-0.45	-2.13 to 1.23	.60	-0.02	-0.82	-2.38 to 0.74	.30	-0.03	-0.83	-2.53 to 0.87	.34	-0.03
Social problems in neighborhood	0.47	-1.27 to 2.21	.60	0.02	1.20	-0.46 to 2.85	.16	0.05	1.04	-0.74 to 2.82	.25	0.04
T1—Negative parenting factor	-0.69	-2.77 to 1.39	.52	-0.03	-0.43	-2.42 to 1.57	.67	-0.02	0.51	-1.61 to 2.62	.64	0.02
T1—Family deviancy factor	0.78	-1.04 to 2.60	.40	0.03	0.61	-1.03 to 2.25	.47	0.02	1.06	-0.70 to 2.81	.24	0.04
T1—Parent mental health factor	-0.90	-3.27 to 1.47	.46	-0.03	-0.98	-3.19 to 1.23	.38	-0.04	-1.53	-3.90 to 0.83	.20	-0.05
T1—Child peer relationships factor	0.13	-1.94 to 2.19	.90	0.00	-0.10	-2.03 to 1.84	.92	0.00	0.72	-1.35 to 2.78	.50	0.03
CB CCS trajectory contrasts												
Early-onset vs never CB CCS	-6.11	11.27 to -0.95	.02	0.24	-3.71	-8.55 to 1.13	.13	0.15	-2.29	-7.46 to 2.88	.39	0.10
Late-onset vs never CB CCS	-3.94	-7.90 to 0.02	.05	0.08	-2.22	-5.86 to 1.43	.23	0.06	-3.74	-7.66 to 0.18	.06	-0.05

TABLE 4 Continued

	Reading			Writing			Math		
	B	95% CI	P	B	95% CI	P	B	95% CI	P
SES interactions with CCS Type									
Trajectories									
Never CB CCS × SES	-17.65	-22.58 to -12.72	.00	-16.45	-21.04 to -11.87	.00	-17.37	22.31 to -12.42	.00
Late-onset CB CCS × SES	-8.44	-15.98 to -0.89	.03	-10.52	-17.76 to -3.27	.00	-7.54	15.50 to 0.41	.06
Early-onset CB × SES	-0.23	-11.92 to 11.47	.97	3.25	-8.11 to 14.61	.57	-1.19	14.60 to 12.21	.86
R ²	0.15	—	—	0.17	—	—	0.13	—	—
F	10.64	—	<.001	12.83	—	<.001	8.85	—	<.001

CB, center based; CI, confidence interval; T1, Time 1, 5 months to 5 years.

5 months to 4.5 years).¹⁶ These services are usually provided in a homelike setting to children of different ages and with less focus on structured activities than in center-based CCS. Center-based CCS are provided to groups of children of similar ages in an educational setting.^{28,29} There is evidence that age segregation promotes higher quality care and education³⁰ and this may be among the reasons why larger effects are achieved for center-based CCS.

Previous publications from United States-based *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Early Childhood Comprehensive System reported associations between higher child-care quality and academic achievement at 15 years,^{13,14} as well as a higher cognitive performance among low-SES children at 4.5 to 11 years.³¹ However, to our knowledge, there is no reporting from the institute of differential effects of CCS for low- and adequate-SES children comparing different features of CCS, such as intensity and type.

Our interaction results are consistent with, and extend longitudinally, previous reports on this sample of cognitive benefits of CCS at school entry,¹⁰⁻¹² and at 3- to 7-years among children of low-educated mothers.¹⁰⁻¹² Not only were the benefits of CCS for low-SES children maintained until the end of sixth grade (12-years) and unexplained by cognition (7-year-old; mothers') or the home environment,¹⁶ but they were substantial and eliminated the disparities in academic performance between low- and adequate-SES children.¹⁶

This study has many strengths. Because sample sizes are often relatively small in CCS studies—7 the large population-based sample allowed detection of SES moderation effects while also controlling for a large array of confounding factors. Also, using early childhood adversity factors enabled us to include a

comprehensive number of longitudinally pertinent selection bias factors (or confounders). Having access to standardized population-based examinations substantially increased the reliability of our outcomes. Finally, with the repeated CCS assessments during early childhood, we were able to take into account time-specific missing data and transitions across CCS types by measuring CCS developmental trajectories. Beyond providing a time-sensitive pictorial display of CCS data, these analyses use FIML and thus include subjects with at least 1 assessment point. Note also that attrition before age 5 was only 2%.

The study is not without limitations. First, as with all longitudinal studies, there was differential attrition over time associated with sociodemographic characteristics. To address this issue, we calculated propensity score weights to make the analysis sample comparable to the original sample (at 5 months) on demographic characteristics.¹⁶ Another limitation relates to selection effects, which may partly explain the findings because families who use CCS can be different from those who do not on unmeasured variables. Randomly assigning children to different types of care would better control for selection bias, yet such trials are difficult to conduct for ethical reasons. Consequently, results of correlational studies carefully controlling for selection bias represent a good approximation to the true effects of child care.

To address the limitations, we controlled for a careful selection of confounders. The breadth of our control variables (eg, 108 family variables summarized in factor scores¹⁶), the quality of our outcome variables (1 standardized ministerial examinations), the longitudinal nature of our CCS predictors, as well as the fact that our pattern of results was previously

found with school entry academic performance¹¹ offers reassurance in the validity of our findings. Still, the correlational design prevents us from making causal inferences, and generalization of findings should be limited to populations with similar CCS (eg, low multiplicity in child-care arrangements).

CONCLUSIONS

Altogether, high-intensity CCS exposure (any type) and early-onset center-based CCS were associated with better academic achievement scores in reading, writing, and mathematics among low-SES children at 12 years, thus reducing or eliminating, in the case of center-

based CCS, the differences in academic achievement between children of low- and adequate-SES background. These results confirm the importance of social policies that will facilitate access to CCS for socially disadvantaged children and thus argue against child-care cuts as currently seen in Canada and the United States.

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ABBREVIATIONS

CCS: child-care services

CSNR: Cumulative Score for Neonatal Risk

ES: effect size

FIML: full information maximum likelihood

QLSCD: Quebec Longitudinal Study of Child Development

SES: socioeconomic status

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