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1 Impact of a social skills program on children's stress: A cluster randomized trial

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24 **Author contributions**

25 SMC, IOM, FV, MPL, MCG, and RET conceived and designed the study. SMC, MPL, IOM, and  
26 MA drafted the manuscript. RET, FV, MCG and IOM reviewed the manuscript. All authors read  
27 and approved the final manuscript after revising it critically for important intellectual content. All  
28 authors agreed to be accountable for all aspects of the work.

29

1

**Abstract**

2 **Background:** Most preschool children in Western industrialized countries attend child care  
3 during the day while parents work. Studies suggest that child care may be stressful to young  
4 children, perhaps because they still lack the social skills to interact daily in a group setting away  
5 from parents. This gap in social abilities may be greater for children in lower-income families,  
6 who may face more adversity at home, with fewer resources and more social isolation.

7 **Methods:** We conducted a cluster-randomized controlled trial in 2013-2014 to test whether a  
8 social skills intervention led by early childhood educators within the child care center could  
9 reduce diurnal cortisol levels to more typical patterns expected of children this age. We  
10 randomized 19 public child care centers ( $n = 361$  children) in low-income neighborhoods of  
11 Montreal, Canada, to either: 1) the Minipally program – intervention group ( $n = 10$  centers; 186  
12 children), or 2) waiting list – control group ( $n = 9$  centers; 175 children). Saliva samples for  
13 cortisol levels were collected 3 times/day, pre- and post-implementation. The Minipally puppet  
14 program consists of 2 workshops/month for 8 months for the development of social skills and  
15 self-regulation in 2-5-year-olds, with reinforcement activities between workshops. Educators  
16 received 2-days' training and 12 hours' supervision in Minipally.

17 **Results:** Linear mixed models for repeated measures revealed a significant interaction between  
18 intervention status and time of day of cortisol sampling ( $\beta = -0.18$ ,  $p = 0.04$ ). The intervention  
19 group showed patterns of decreasing diurnal cortisol secretion ( $\beta = -0.32$ ,  $p < 0.01$ ), whereas  
20 the control group showed increasing slopes ( $\beta = 0.20$ ,  $p < 0.01$ ). Moreover, family income was a  
21 moderator; children in lower-income families benefited most from the intervention.

22 **Conclusion:** Results suggest that a social skills training program, when integrated into a  
23 preschool education curriculum, can foster an environment more conducive to typical childhood  
24 patterns of cortisol secretion.

25

26 *Keywords:* Child care, daycare, social skills training, cortisol, diurnal cortisol, low income

1 *Abbreviations:* HPA, Hypothalamic-pituitary-adrenal.

2

3 **Trial registration number:** ISRCTN84339956 (retrospectively registered in March 2017, no  
4 amendment to initial protocol).

5

1 Impact of a social skills program on children's stress: A cluster randomized trial

## 2 **1. Introduction**

3 In most Western industrialized countries, the percentage of preschool children receiving child  
4 care services has increased dramatically since the mid-1980s (OECD, 2014). In this context, we  
5 will use the term "child care" to designate a daycare center; i.e. a preschool or regular group-  
6 based care of children prior to school entry by someone other than the parents, who are  
7 generally at work. In the majority of countries belonging to the Organization for Economic Co-  
8 operation and Development (OECD), it is estimated that at least 80% of children receive full-  
9 time child care before they enter elementary school (OECD, 2014). Child care constitutes a  
10 promising and supportive environment, especially for children from socioeconomically  
11 disadvantaged neighborhoods, in at-risk families, or with early socioemotional maladjustment  
12 (Côté et al., 2007; Herba et al., 2013).

13 For many children, child care represents the first social experience in a structured group  
14 setting. Although child care is associated with a number of head start benefits for school  
15 readiness (higher receptive vocabulary and reading skills), particularly for children from low  
16 socioeconomic levels (Geoffroy et al., 2010), child care may also be a stressful experience,  
17 especially for younger children or those attending lower-quality establishments (Ouellet-Morin et  
18 al., 2010; Watamura et al., 2002). Two meta-analyses have reported that preschoolers (3–5  
19 year-olds) tended to secrete higher diurnal levels of cortisol, the so-called "stress hormone",  
20 when attending child care as compared to staying home (Geoffroy et al., 2006; Vermeer and  
21 van Ijzendoorn, 2006). These flat or increasing patterns of cortisol secretion differ from the  
22 gradually decreasing pattern biologically expected for children this age (Watamura et al., 2009).

### 23 *1.1 Child Care Center as a Stressful Environment*

24 The child care environment may be perceived by young children as unpredictable,  
25 uncontrollable, and more threatening than their own home. Repeated and intense activation of

1 the hypothalamic-pituitary-adrenal (HPA) axis may lead to flattened or increasing diurnal cortisol  
2 secretion (Gunnar et al., 2009). Although there is no evidence of a direct link between stress in  
3 child care settings and poor health outcomes, chronic exposure to high levels of stress has  
4 been shown to negatively impact child health (Koss and Gunnar, 2017). Furthermore, tolerable  
5 and environmentally adaptive stress was shown to be associated to well-being (Gunnar and  
6 Quevedo, 2007), warranting interventions that target potential sources of stress in child care  
7 centers.

8 Two characteristics associated with the child care environment may induce stress and  
9 activation of the HPA axis. First, developmentally, the age group in child care centers coincides  
10 with peak levels of physically aggressive behaviors in response to conflict. This increases the  
11 probability of victimization or of witnessing physical aggression (Côté et al., 2006). Indeed,  
12 being either the perpetrator or the victim of physically aggressive behaviors may lead to high  
13 levels of peer rejection, which in turn is also associated with rising cortisol patterns in children  
14 attending child care (Gunnar and Donzella, 2002).

15 Second, preschoolers may not have reached sufficient levels of emotion regulation  
16 (Gunnar and Donzella, 2002) to engage in prosocial behaviors. Emotion regulation has been  
17 described as the ability to process emotions and emotional information, including inhibition of  
18 emotional impulses, modulation of emotional behavior, and disengagement from distressing  
19 elements (Grolnick & al., 2006). In children with poor emotion regulation skills, the risks of  
20 disruptive behavior, poor social skills, and peer rejection are increased (Gunnar et al., 2003).

### 21 *1.2 Targeted Interventions for Children Attending Child Care Centers*

22 Results from relationship-focused interventions targeting children exposed to early life adversity,  
23 such as foster care and neglect, suggest that improving the quality of the caregiver-child bond  
24 may foster optimal HPA-axis activity (Bernard et al., 2015). To the best of our knowledge, only  
25 one study tested the hypothesis that teacher-child relationships in child care could impact  
26 cortisol levels (Hatfield and Williford, 2017). The objective of their 7-week program was to foster

1 sensitive teacher-child relationships and prosocial interactions among disruptive children (n =  
2 113). Lower cortisol levels in the morning were observed for children exposed to the intervention  
3 as compared to the control group. These results suggest that a psychosocial program within the  
4 child care environment can modify HPA-axis activity.

### 5 *1.3 Targeted Interventions for Child Care Centers in Low-Income Neighborhoods*

6 Low-income neighborhoods present a confluence of distal and proximal challenges thought to  
7 influence biological, cognitive, and behavioral development in children (Koss and Gunnar,  
8 2017). Specifically, child care centers in low-income neighborhoods tend to be fewer and of  
9 lower quality than in higher-income neighborhoods (Cloney et al., 2016). Also, children from  
10 disadvantaged socioeconomic backgrounds are more likely to have cognitive and  
11 socioemotional deficits (Cloney et al., 2016; Goldfeld et al., 2015) which may lead to higher  
12 levels of aggression in the child care setting. However, children from lower-income families also  
13 stand to benefit the most from attending good quality child care, especially in terms of social  
14 development (Côté et al. 2007). Interventions supporting the development of prosocial skills and  
15 emotion regulation in low-income neighborhood child care centers may lower diurnal cortisol  
16 secretion, by reducing the number of conflicts to which the children are exposed. Social skills  
17 training might also buffer HPA-axis activation by lowering levels of peer exclusion, increasing  
18 prosocial interactions with peers, and encouraging children to ask for help from a trusted  
19 caregiver (Hostinar and Gunnar, 2015).

### 20 *1.4 Study Aims and Hypothesis*

21 We conducted a cluster randomized controlled trial of a training program for early childhood  
22 educators to implement in child care centers of low-income neighborhoods. The aim was to test  
23 whether preschoolers attending a child care center with a social skills intervention component,  
24 by educators with specific training, showed more normative patterns of diurnal cortisol secretion  
25 than children not exposed to such a program. Additionally, we tested whether the impact of the

1 intervention varied as a function of family income, whereby children from lower-income families  
2 were hypothesized to benefit the most from social skills training.

3

## 4 **2. Methods**

### 5 *2.1 Participants*

6 We conducted the study in low-income neighborhoods of Montreal, Quebec, Canada from  
7 September 2013 to June 2014. Eligibility criteria were that at least 25% of the children attending  
8 the child care come from low-income families, defined as those entitled to a special government  
9 subsidy providing free child care access to families with an annual family income below  
10 Can\$20,000. The income status of the neighborhood itself was defined according to both  
11 provincial (Québec., 2013) and national criteria (Canada, 2011). Children were not clustered in  
12 particular child care centers by familial income and the distribution of family income was not  
13 uniform across child care centers, allowing us to investigate the moderating effect of family  
14 income on intervention status and cortisol secretion. Of 38 child care centers manifesting an  
15 interest, 19 were eligible. We determined that a sample of 19 centers would allow us to detect a  
16 small-to-medium effect size, with 90% power at a two-sided significance level of 5% (Heo,  
17 2008).

### 18 *2.2 Study Design*

19 Randomization was at the level of the child care center. Centers were randomized to receive the  
20 Minipally social skills program in Year 1 (intervention group) or Year 2 (waiting list, control  
21 group). Each child care center included 2-3 classes of 4-year-olds, with 8 children per class.  
22 Altogether, 43 classes ( $n = 361$  children) in 19 child care centers took part in the study (Figure  
23 1). Cluster randomization ensured that children from the control (waiting list) group were not  
24 exposed to the intervention. The intervention team provided Minipally training to the educators,  
25 and the research team evaluated the impact of the intervention. Once data collection was  
26 complete, all child care centers in the control group received the Minipally training. Consent to



1 participate in the study was obtained from parents and child care directors. The Sainte-Justine  
2 Hospital Research Ethics Board approved all procedures in May 2013. A detailed description of  
3 the study protocol has been published (Côté et al., 2017).

4 Insert Figure 1 here

### 5 *2.3 Intervention*

6 The intervention was the Minipally program for the development of social skills and self-  
7 regulation in children aged 2 to 5 years. The Minipally curriculum is delivered via a puppet that  
8 presents itself as a loyal and enthusiastic friend visiting the child care to model prosocial  
9 behaviors and social inclusion. There are 16 play sessions (2/month for 8 months) where the  
10 educators and puppet discuss/play with friends (other puppets) and the children. The program  
11 includes generic components of social skills training for children: introduction to social contact  
12 (make and accept contact from others, make requests); problem-solving (identifying the  
13 problem, generating solutions); self-regulation (breathing to calm down, accepting frustration,  
14 learning to share, tolerating frustration); and emotion regulation (identifying and expressing  
15 emotions, listening to others).

16 Child care educators at centers randomized to the intervention received 2 days of  
17 intensive training in the Minipally program plus 12 hours of classroom supervision (4 half-day  
18 sessions over the course of the program). After each Minipally session with the children,  
19 educators reinforced the principles with 2 weeks of activities based on the topic addressed (for  
20 instance, if the Minipally puppet intervened in a particular way in a conflict between two children,  
21 then over the next 2 weeks, the educator designed activities to recall the strategies presented  
22 by the puppet).

## 23 **3. Measures**

### 24 *3.1 Saliva Collection*

25 Saliva samples were collected before and after the intervention by trained research assistants  
26 blinded to the status of the child care center (intervention or control). Samples were collected at

1 3 time points: 1) 30 minutes after the child's arrival at child care (between 7:00 and 10:30 a.m.);  
2 2) before lunch (between 10:45 a.m. and 12:00 a.m.); and 3) one hour after waking from the  
3 afternoon nap (between 2:30 and 4 p.m.). Saliva was collected by placing a cotton sponge  
4 under the child's tongue for one minute (SalivaBio Children's Swab, Salimetrics).

5 Samples were stored at -20°C until the laboratory assays. Cortisol concentration was  
6 obtained using a high-sensitivity enzyme immunoassay where the lowest limit of detection was  
7 0.007µg/dL. All samples were assayed in duplicate. The intra- and inter-assay coefficients of  
8 variation were 4.46% and 8.28%, respectively.

### 9 *3.2 Parent Questionnaires*

10 Parents answered a short questionnaire upon arrival at the child care center, both before and  
11 after the intervention. Questionnaires included a wide range of variables potentially affecting  
12 cortisol secretion, such as children's habits and waking time, foods eaten for breakfast, current  
13 medication, sleep quality the night before, current mood (sad, excited), and state of health (cold,  
14 allergies).

15 Information on sociodemographic background (parent education and family income) was  
16 collected before the intervention. Annual family income ranged from "less than Can\$10,000" to  
17 "more than Can\$80,000." Because the income distribution was not uniform, and to ensure a  
18 similar number of children in each group, we split the sample into three: lower-income families  
19 entitled to government subsidy (income less than Can\$20,000), middle-income families  
20 (Can\$20,000 to Can\$80,000), and higher-income families (over Can\$80,000).

### 21 *3.3 Children's Social Behaviors Assessed by Child Care Educators*

22 Educators completed the social behavioral questionnaire (Tremblay et al., 1992) for each child  
23 in their group at pre- and post-intervention. Two dimensions of the validated and well-published  
24 questionnaire (Pingault et al., 2011) were used: a) disruptive behaviors including five items on  
25 opposition (e.g., has been defiant or has refused to comply with an adult request); four on  
26 impulsivity/hyperactivity questions (e.g., has had difficulty waiting for his/her turn in games); six

1 on physical aggression questions (three reactive, e.g., has reacted in an aggressively when  
2 teased, and three non-reactive, e.g., has gotten into fights) (Cronbach alpha = 0.86); and b)  
3 prosocial behaviors (e.g., has helped other children; 7 items) (Cronbach alpha = 0.79).

#### 4 *3.4 Child Care Educator Questionnaires*

5 Every educator completed a sociodemographic questionnaire as well as a questionnaire  
6 assessing their training in early childhood education and care. Educators in the intervention  
7 group also completed a logbook in which they indicated when and which Minipally activities had  
8 been conducted in their group.

### 9 **4. Data Analysis**

#### 10 *4.1 Preliminary analyses*

11 We compared the intervention and control groups at baseline for 35 variables that might directly  
12 or indirectly affect the impact of the intervention, including age, family income and number of  
13 hours of child care per week. Less than 6% of the variables differed between groups,  
14 suggesting that randomization was successful. Nonetheless, we verified whether those  
15 variables were associated with diurnal cortisol secretion. None were, so we did not control for  
16 them in subsequent models.

17 Second, we identified outlier values for which the cortisol concentration was above 3  
18 standard deviations of the sample mean. At each saliva sample collection time, there were 2-5  
19 outliers (for a total of 23); these were winsorized so as not to exert undue influence on the  
20 results. We then performed a square root transformation of the cortisol distribution at each time  
21 point to account for skewness. We used bivariate analyses (Spearman correlation coefficients  
22 and ANOVA) to search for potential covariates associated with cortisol levels, such as exact  
23 hour of sampling. For each cortisol sample, we modeled multiple variable linear regressions  
24 using the following independent variables: exact hour of sampling, time of awakening, hours  
25 since last saliva sample and all potential confounders related to cortisol secretion. We derived  
26 the residuals from each linear regression (i.e. one regression for every cortisol sample) so that

1 the main analyses would be free from potential confounders. Raw cortisol concentration and  
2 residual concentration at each sample time according to intervention groups are presented in  
3 Table S3 in Supplementary material.

#### 4 *4.2 Main Analyses*

5 To test the impact of the intervention on diurnal cortisol secretion (i.e. cortisol change during the  
6 day), we used linear mixed models for repeated measures. This method allows the modeling of  
7 multiple data points nested within individuals while also modeling between-subject differences.  
8 Accounting for non-independence of repeated measures, linear mixed modeling allowed for the  
9 possibility that cortisol samples taken on the same day in any given child might be more  
10 correlated than samples in different children. Each child was assigned an individual intercept  
11 and slope of diurnal cortisol secretion. Patterns were adjusted for missingness. The final model  
12 represents the mean effect of every intercept and slope (i.e. diurnal cortisol secretion) according  
13 to intervention status (intervention vs. control). We did not include an additional level for child  
14 care as the intracluster correlation coefficient for child care was less than 5%. Analyses with and  
15 without this level yielded similar results, so we reported the most parsimonious model  
16 (Tabachnick and Fidell, 2007).

17 Linear mixed modeling was conducted pre-and post-intervention. At each time point, the  
18 fixed effects were intervention status (intervention vs. control), time of saliva collection (morning  
19 [0], just before lunch [1], and one hour after waking from the afternoon nap [2]), and interaction  
20 (intervention status x time of saliva collection). At post-intervention, we also controlled for pre-  
21 intervention cortisol levels. We also examined whether the effects of the intervention varied  
22 according to family income. More specifically, we tested a three-way interaction including  
23 intervention status, time of saliva collection, and family income. All analyses were conducted  
24 using IBM SPSS Statistics, version 24 (Armonk, NY, USA).

25

## 26 **5. Results**





1 sample ( $F = 27.34$ ,  $df = 114$ ,  $p < 0.01$ ) where children from low and middle-income families had  
2 their lowest level of diurnal cortisol concentration.

### 3 *5.4 Supplementary analyses.*

4 To explore the possibility that the impact of the intervention occurred via changes in child  
5 behaviors, we tested whether disruptive and prosocial behaviors assessed by child care  
6 educators in post-intervention mediated the effect of the intervention on cortisol secretion.  
7 Specifically, we used two formulas for the calculation of overall diurnal cortisol secretion by  
8 areas under the curve: 1) the “Area under the curve with respect to increase” (AUCI) and “Area  
9 under the curve with respect to ground” (AUCG) (Pruessner et al., 2003). Using these  
10 outcomes, intervention status was associated with AUCG ( $\beta = -1.62$ ,  $p = 0.01$ ), and not with  
11 AUCI ( $\beta = -1.32$ ,  $p = 0.07$ ). The intervention was also associated with a significant decrease of  
12 children’s disruptive behaviors in post-intervention ( $\beta = -0.61$ ,  $p = 0.02$ ), but disruptive behaviors  
13 were not associated with children’s AUCG ( $\beta = -0.09$ ,  $p = 0.52$ ) or AUCI ( $\beta = 0.03$ ,  $p = 0.85$ ).  
14 The intervention was not associated with an increase of children’s prosocial behaviors in post-  
15 intervention ( $\beta = 0.38$ ,  $p = 0.09$ ), and prosocial behaviors were not associated with children’s  
16 AUCG ( $\beta = 0.01$ ,  $p = 0.99$ ) or AUCI ( $\beta = 0.01$ ,  $p = 0.63$ ). Thus, neither disruptive nor prosocial  
17 behaviors in post-intervention were predictors of overall cortisol secretion. Finally, we  
18 investigated if family income was also a moderator of the association between intervention  
19 status and children’s social behaviors in the mediation models between intervention status and  
20 children’s overall diurnal cortisol secretion. We did not find a significant moderation by familial  
21 income for disruptive behaviors ( $p = 0.30$ ) neither for prosocial behaviors ( $p = 0.65$ ).

22

23

Insert Table 2 here

24

Insert Figure 3 here

25

## 1       **6. Discussion**

2       Young children in child care have been reported to exhibit flat levels of diurnal cortisol secretion,  
3       as opposed to the decreasing pattern expected for children that age (Vermeer and van  
4       Ijzendoorn, 2006; Watamura et al., 2002). We conducted a cluster randomized controlled trial to  
5       test whether a social skills training program, led by early childhood educators in child care  
6       centers, would restore expected patterns. Whereas both the intervention and control groups in  
7       participating child care centers exhibited flat diurnal cortisol secretion at baseline, we found that  
8       children exposed to the intervention exhibited more typical, decreasing levels of cortisol  
9       secretion throughout the day, as compared to controls. Further, children from lower-income  
10      families seemed to benefit more from the intervention than those from middle- or higher-income  
11      backgrounds. Interestingly, in the intervention group, children from higher-income families had  
12      diurnal patterns characterized by early suppression of morning cortisol, whereas children from  
13      middle- and low-income families had greater cortisol suppression in the afternoon, as compared  
14      to controls.

15           A possible explanation for the sharper decline in the diurnal cortisol slope in children  
16      from lower-income families is that they may be more sensitive than others to the intervention  
17      and to the ensuing changes in the child care environment. Children from disadvantaged  
18      backgrounds are more likely to be disruptive (Shaw and Shelleby, 2014) and to be victimized in  
19      peer-play interactions (Barker et al., 2008). The social skills intervention might have enhanced  
20      the dynamic of the group as a whole, thereby helping the children most at risk. Fewer social  
21      challenges and confrontations in the intervention group might explain the observed cortisol  
22      decreases. For the control group, the increasing cortisol levels observed for low- and middle-  
23      income children similarly point to the idea that these children were in need of an intervention  
24      fostering a less stressful environment.

25           A complementary hypothesis is that children from higher-income families might be more  
26      sensitive to age-appropriate social challenges in the child care setting, as compared to children



1 from middle- or lower-income families, assuming that children from higher-income families faced  
2 fewer challenges in their home environment (Ellis and Boyce, 2008). For children of higher-  
3 income families in both the intervention and control groups, the child care environment might  
4 still be perceived as unpredictable and uncontrollable, two features associated with greater  
5 cortisol response (Gunnar et al., 2009). The diurnal patterns observed in this study support the  
6 idea that HPA-axis activation in child care is an adaptive reaction to the perception of challenge  
7 and unpredictability in the environment. More generally, these findings support the concept that  
8 children exposed to different levels of adversity will perceive threats differently and react to them  
9 differently in daily life (Ellis and Del Giudice, 2014).

10 Finally, we note that our results are in line with those reported by Berry and colleagues  
11 (Berry et al., 2016; Berry et al., 2014), where children in child care from lower socioeconomic  
12 status exhibited lower levels of diurnal cortisol than their wealthier peers. However, despite  
13 similarities between our results and those obtained in the Family Life Project (Berry et al., 2016;  
14 Berry et al., 2014), the mechanisms underlying interactions between family income and diurnal  
15 cortisol secretion remain largely unclear and there is some not-yet-understood complexity in the  
16 present results.

17 To the best of our knowledge, there is no longitudinal study examining the impact of high  
18 stress levels on later physical and mental health in children who regularly attend child care. We  
19 are therefore limited in the discussion of potential long-term effects of our intervention on well-  
20 being and development. Future studies should investigate the consequences of flattened and  
21 increasing diurnal cortisol secretion in children attending child care, as it is a developmental and  
22 context-specific phenomenon that has been replicated several times in different welfare systems  
23 (Geoffroy et al., 2006; Vermeer and van Ijzendoorn, 2006).

24 It is important to emphasize three features of the social skills program evaluated in this  
25 study. First, the program is inclusive—all children are involved in the social skills training—not  
26 only those exhibiting socioemotional or behavioral problems. This lowers the total cost of the

1 intervention and notably, reduces the risk of stigma in children. Second, the program can easily  
2 be integrated into daily routine and educational activities, thus increasing adherence levels of  
3 early childhood educators to the program. Third, the program can be disseminated with  
4 relatively low implementation costs and educator training. Dividing the total expenses for  
5 program implementation (educator training, supervision, and monetary compensation to child  
6 care directors) by the number of children who received the intervention ( $n = 185$ ), the total  
7 cost/child works out to Can\$95.

8 It is noteworthy that we did not find an association between social behaviors (either  
9 disruptive or prosocial) and diurnal cortisol secretion in supplementary analyses. Further  
10 research will be needed to address the potential effect of social skills training on peer-peer  
11 relationships, educator-child relationship, the degree of classroom chaos, and the social  
12 behaviors of the group to identify the mechanisms involved in the interaction between the  
13 intervention and HPA-axis activation.

#### 14 *6.1 Strengths and Limitations*

15 The main strengths of this study are its cluster-randomized experimental design and the  
16 measurement of diurnal cortisol levels three times per day to determine secretion patterns.  
17 Further, cortisol samples were collected by our research assistants, ensuring that collection  
18 procedures such as sampling time were uniform throughout. The study has high ecological  
19 validity; it was conducted in community-based child care centers, with early childhood educators  
20 whose qualifications were the two-year college program in early childhood and child care  
21 education required by the Quebec government (as compared to fully licensed psychologists,  
22 teachers, or social workers). Finally, our sample was sufficiently heterogeneous to justify testing  
23 family income as a moderator between intervention status and diurnal cortisol secretion.

24 The study also had some limitations. First, 6% of the children left child care over the  
25 course of the study. While for the most part, the family sociodemographic characteristics of  
26 newcomers were no different from those who left, we could not statistically control for pre-

1 intervention cortisol secretion in children who joined the study later. Second, we do not know the  
2 exact number of workshops animated by child care educators. We only know that 90% of the  
3 educators performed 12 or more workshops out of 16 during the year of implementation. Future  
4 studies should include comprehensive implementation evaluation. Third, as we did not collect  
5 longer-term post-intervention cortisol samples, we did not test whether the reported differences  
6 persisted over time. Similarly, we did not test whether the observed decline in cortisol secretion  
7 was associated with a lower risk of behavioral difficulties later on. Such investigation would have  
8 required additional time points to test this hypothesis according to a clear temporal sequence  
9 where the HPA axis would be a mediator between the psychosocial intervention targeting  
10 quality child care and disruptive behavior. Replication of this study with long-term follow-up,  
11 larger sample size, and different models of child care (center-based vs. home-based) is needed  
12 to advance knowledge on the mechanisms linking child care quality to diurnal patterns of  
13 cortisol secretion and long-term social and emotional development.

14

## 15 **7. Conclusion**

16 Our findings suggest that a social skills training program, when integrated into a preschool  
17 education curriculum, can foster an environment more conducive to typical childhood patterns of  
18 cortisol secretion. Given that child care services cover a critical developmental period during  
19 which young children learn to interact in a group setting, this program may be a promising way  
20 to ensure and promote health and well-being from an early age.

21

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1

2 **Figure Legends**

3 **Figure 1.** Trial Flow Diagram

4

5 **Figure 2.** Post-intervention diurnal cortisol secretion, according to intervention status

6 Abbreviations: AM, morning; PM, afternoon.

7 Note: Post-intervention refers to 8 months after the start of the intervention.

8

9 **Figure 3.** Post-intervention diurnal cortisol secretion, according to family income and

10 intervention status

11 Abbreviations: AM, morning; PM, afternoon.

12 Note 1. Post-intervention refers to 8 months after the start of the intervention.

13 Note 2. Cortisol concentration residuals were derived from the three-way interaction between  
14 family income, intervention status, and time of day.

15

16 **Supplementary Material**

17 **Figure S4.** Post-intervention diurnal cortisol secretion, according to intervention status and

18 family income

19 Abbreviations: AM, morning; PM, afternoon.

20 Note 1. Post-intervention refers to 8 months after the start of the intervention.

21 Note 2. Cortisol concentration residuals were derived from the three-way interaction between  
22 family income, intervention status, and time of day.

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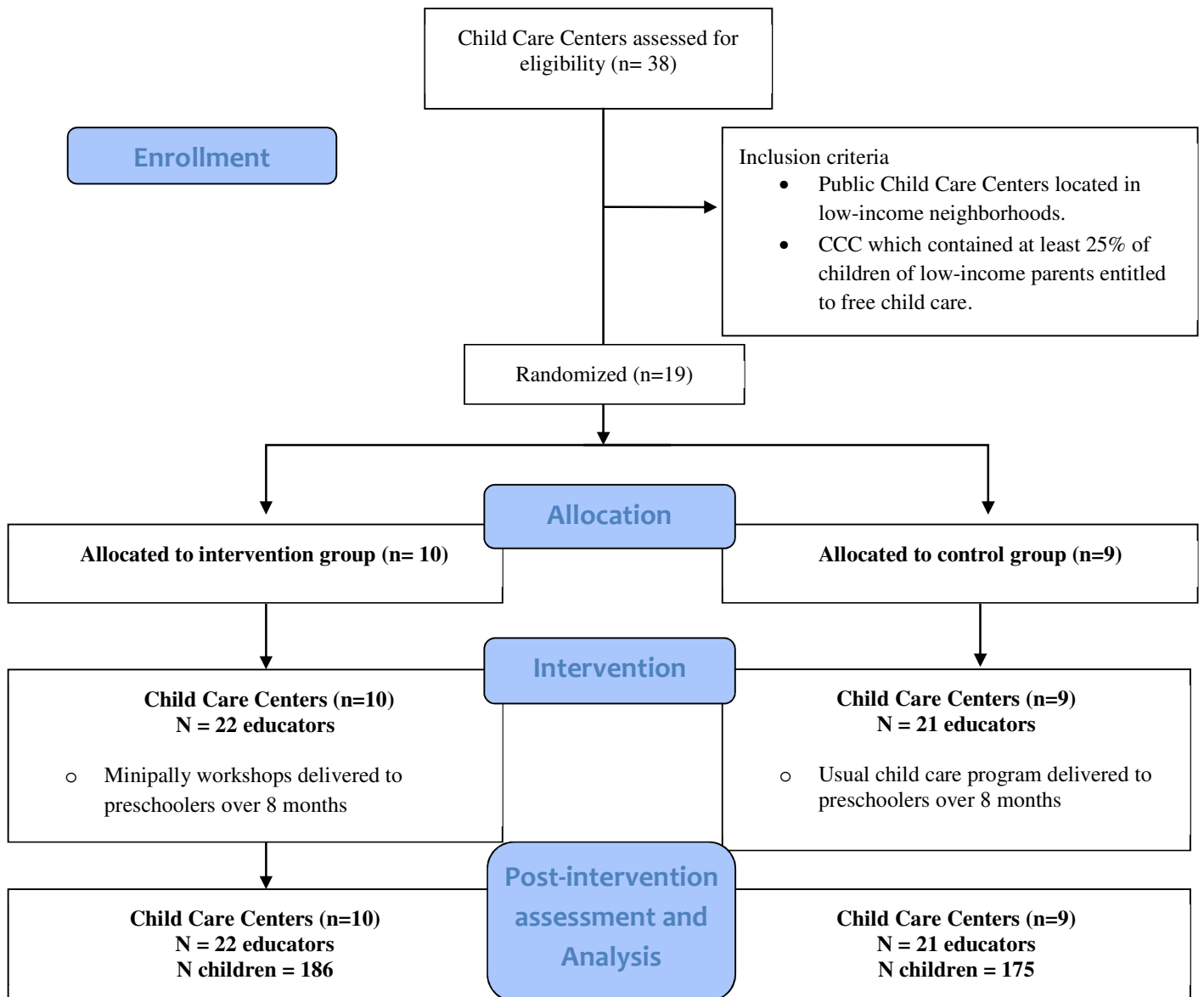
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**Figure 1. Trial Flow Diagram**

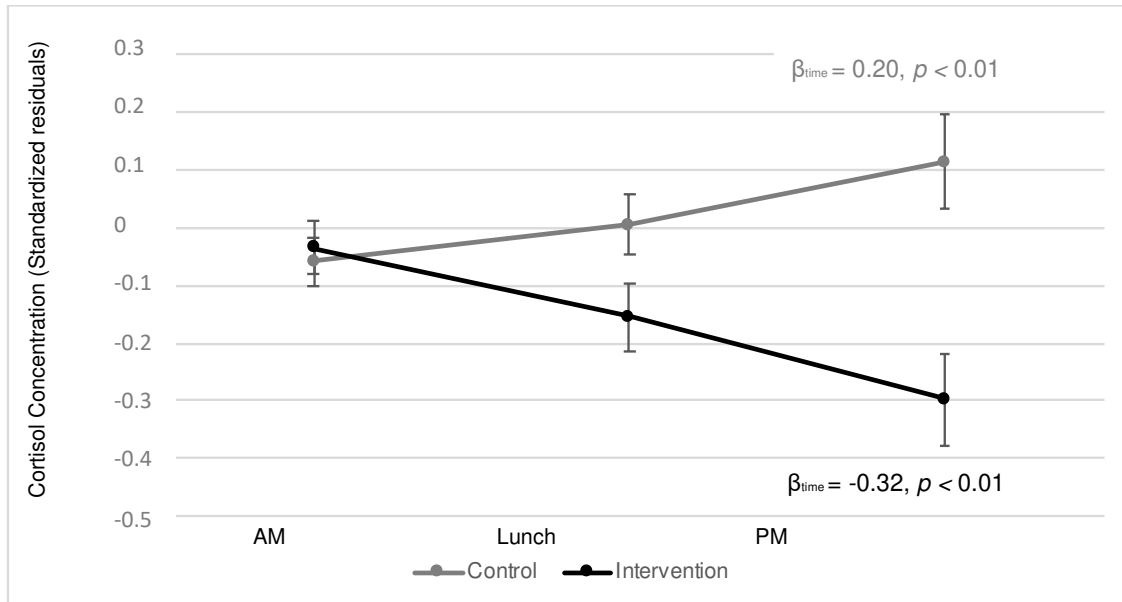


**Table 1.** Children's descriptive statistics at baseline

	Control group (n = 175)	Intervention group (n = 186)	<i>P</i> value
Age, months <sup>a</sup>	52.8 (5.0)	54.5 (4.5)	< 0.01
Sex ( <i>boy</i> ) <sup>b</sup>	86 (49.1%)	98 (52.7%)	0.57
	164	165	
Have siblings <sup>b</sup>	128 (78.5%)	143 (86.7%)	0.12
	163	165	
Child care hours/week <sup>b</sup>			
< 30 hours	24 (14.6%)	35 (21.2%)	0.26
30-40 hours	104 (63.4%)	95 (57.6%)	
> 40 hours	36 (22.0%)	35(21.2%)	
	164	165	
Family income <sup>b</sup>			
< Can\$19 999	34 (21.7%)	23 (14.7%)	0.26
Can\$20 000-80 000	69 (43.9%)	71 (45.5%)	
> Can\$80 000	54 (34.4%)	62 (39.7%)	
	157	156	
Highest maternal education <sup>b</sup>			
High school diploma	20 (12.7%)	21 (13.1%)	0.53
Vocational training	49 (31.0%)	48 (30.0%)	
Bachelor's degree	67 (42.4%)	60 (37.5%)	
Master's or PhD	22 (13.9%)	31 (19.4%)	
	158	160	

<sup>a</sup> Mean (SD).<sup>b</sup> n (%).

**Figure 2.** Post-intervention diurnal cortisol secretion, according to intervention status



Abbreviations: AM, morning; PM, afternoon.

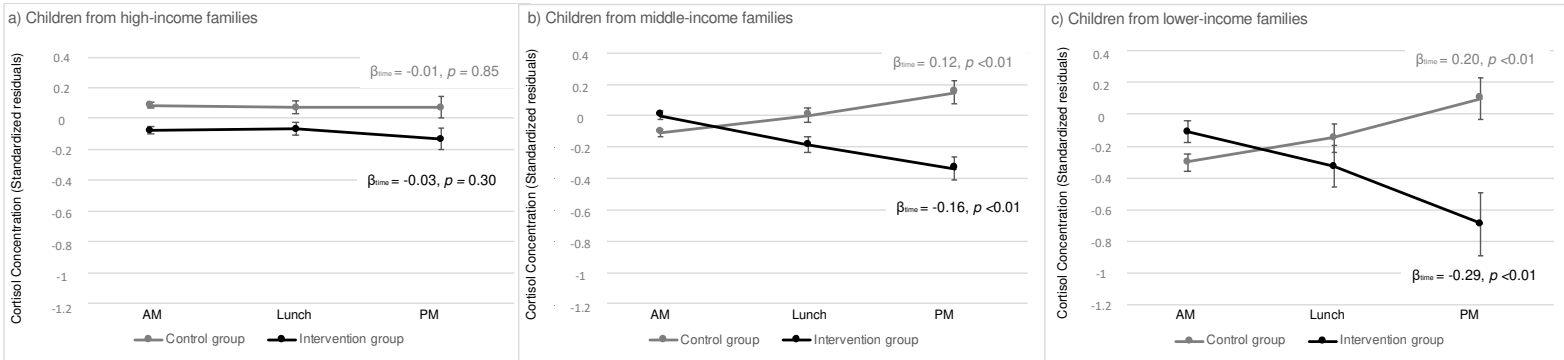
Note: Post-intervention refers to 8 months after the start of the intervention.

**Table 2.** Post-intervention diurnal cortisol secretion, according to family income and intervention status

	$\beta$ (95% CI)	<i>P</i> value
Intercept	-0.63 (-1.08, -0.17)	0.01
Pre-intervention cortisol levels	0.18 (0.11, 0.26)	< 0.01
Intervention	0.53 (-0.16, 1.23)	0.13
Time	0.38 (-0.01, 0.76)	0.05
Time x intervention	-0.79 (-1.36, -0.22)	0.01
Income	0.26 (0.06, 0.45)	0.01
Income x intervention	-0.23 (-0.53, 0.07)	0.13
Income x time	-0.14 (-0.30, 0.02)	0.09
Income x intervention x time	0.27 (0.02, 0.51)	0.03

Abbreviation: CI, confidence interval.

**Figure 3.** Post-intervention diurnal cortisol secretion, according to family income and intervention status



Abbreviations: AM, morning; PM, afternoon.

Note 1. Post-intervention refers to 8 months after the start of the intervention.

Note 2. Cortisol concentration residuals were derived from the three-way interaction between family income, intervention status, and time of day.