ORIGINAL ARTICLE

The Role of Maternal Education and Nonmaternal Care Services in the Prevention of Children's Physical Aggression Problems

Sylvana M. Côté, PhD; Michel Boivin, PhD; Daniel S. Nagin, PhD; Christa Japel, PhD; Qian Xu, MSc; Mark Zoccolillo, MD; Marianne Junger, PhD; Richard E. Tremblay, PhD

Context: Physical violence is an important health problem, and low maternal education is a significant risk for the development of chronic physical aggression (PA). We hypothesized that nonmaternal care (NMC) services could prevent the development of childhood PA problems, depending on the age at which the services are initiated.

Method: Children who followed a trajectory of atypically frequent PA between 17 and 60 months of age among a population sample of 1691 Canadian families were identified. Maternal education and NMC were considered in predicting group membership while controlling for confounding family characteristics.

Results: Children of mothers with low education levels (ie, no high school diploma) were less likely to receive NMC. Those who did receive such care had significantly lower risk of a high PA trajectory. Results from logistic regressions indicated that NMC reduced the risk of high PA, especially when initiated before age 9 months (odds ratio, 0.20; 95% confidence interval, 0.05-0.90). Children of mothers who graduated from high school were less at risk of PA problems, and NMC had no additional protective effect.

Conclusions: Nonmaternal care services to children of mothers with low levels of education could substantially reduce their risk of chronic PA, especially if provided soon after birth. Because children most likely to benefit from NMC services are less likely to receive them, special measures encouraging the use of NMC services among high-risk families are needed.

Arch Gen Psychiatry. 2007;64(11):1305-1312

Author Affiliations: Departments of Social and Preventive Medicine (Dr Côté) and Psychology and Paediatrics (Dr Tremblay) and Research Unit on Children's Psychosocial Maladjustment (Ms Xu), International Laboratory for Child and Adolescent Mental Health Department, University of Montreal, Québec, Canada, and Inserm U669, Paris, France (Drs Côté and Tremblay); Department of Psychology, Laval University, Québec (Dr Boivin); Carnegie Mellon University, Heinz School of Public Policy, Pittsburgh, PA (Dr Nagin); Department of Education, Université du Québec à Montréal (Dr Japel); Department of Psychiatry, McGill University, Québec (Dr Zoccolillo); and Department of Psychology, Utrecht University, Utrecht, the Netherlands (Dr Junger).

HIGH FREQUENCY OF PHYSICAL aggression (PA) is the central feature of severe conduct disorder[1] and is associated with a wide range of social, mental, and physical health problems.[2-4] The origin of PA problems can be traced back to early childhood, and studies have specifically shown that maternal characteristics, especially low levels of education, are among the best predictors of high PA from early childhood to adolescence.[5-9]

Cross-fostering animal studies show that the negative consequences of poor maternal care can be prevented by providing high-quality surrogate mothering.[10-13] Similarly, in humans, a few experimental studies offering nonmaternal care (NMC) services to young children from high-risk families provide evidence for their protective role.[14,15] However, it is not clear that the effects of such experimental programs, designed to be of the highest quality, are comparable to the effects of NMC services at the population level, which typically are of lower quality.[16] Nonmaternal care services are provided by a person chosen to care for a child, usually during the day when the mother is working. Nonmaternal care includes various types of day care arrangements (family- or center-based) used regularly during the preschool years.

The objective of the present study was to test, with a representative sample of a population, whether NMC services could prevent the development of childhood PA problems and whether the magnitude of the effect varied according to the age at which the child began to receive NMC services.

Most children in present-day industrialized societies receive NMC services during the preschool years.[17,18] Children of mothers with low levels of education, however, are less likely to receive NMC because their mother is less likely to be working.[18,19] Children of mothers with low levels of education are also more likely to be exposed to a wide range of risks in their home, such as poor parenting,[20,21] low levels of stimulation,[20] and poverty.[22] Thus, children of poorly educated mothers (compared with children of better-educated

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

Table 1. Demographic Characteristics of the Sample

Characteristic	No. (%) of 1691 Subjects
Sex	
Female	844 (49.9)
Male	847 (50.1)
Maternal age (birth of target child), y	
<21	1497 (88.5)
>21	194 (11.5)
Maternal education	
High school diploma	1395 (82.5)
No high school diploma	296 (17.5)
Family status	
Intact (married or common-law union)	1551 (91.7)
Separated, divorced, widowed	65 (3.8)
Always single	75 (4.4)
Family annual income, $	
<30 000	543 (32.1)
30 000-60 000	674 (39.9)
>60 000	474 (28.0)
Timing of NMC	
Never in NMC (before school entry)	111 (6.6)
Initiated before age 9 mo	234 (13.8)
Initiated at or after 9 mo	1346 (79.6)

Abbreviation: NMC, nonmaternal care.

mothers) may be exposed to higher risks of PA because they are more likely to spend time in the context of an at-risk home environment.

Therefore, at the most basic level, NMC may be protective because it provides a reduction in exposure to family risks. Within this context, the protective effect should be more pronounced if NMC experiences are initiated earlier in the child's life. Earlier initiation of NMC would not only lead to a greater reduction of exposure to family risk but would do so at younger ages, when the brain and behavior repertoire are more malleable.[23] A recent study found that NMC services during the first year of life were related to better receptive language at 4 years among children of low socioeconomic status.[24] However, to our knowledge, no study has examined the extent to which the timing of NMC initiation (earlier vs later) is related to the long-term development of PA among high-risk children.

To adequately examine the role of NMC in a population-based sample, 2 important issues need to be considered. First, the association between NMC and PA may vary according to children's family risk status. Family risks for PA include low maternal education, low income, parental psychiatric disorders, and poor parenting practices.[5-9,25] While NMC may be associated with better outcomes among the high-risk children,[14,19,26,27] it may be associated with poorer outcomes among children who are not from high-risk families,[25,28] especially if it is initiated in infancy.[29] Indeed, for children who are not from high-risk families, their NMC may be of a lower quality than the care they would receive at home.

Second, the "social selection" of children into NMC can confound the association between NMC and PA problems. If children of less educated mothers are less likely to receive NMC services[19] but are more likely to benefit from them, then NMC services at the population level will not reduce the disparities in PA problems between children of low- and better-educated mothers.[30]

In the present study, we used a population sample of newborns to test the hypothesis that: (1) young children of mothers with low levels of education (no high school diploma) benefit more from receiving NMC services than do children of better-educated mothers and (2) the protective effects are greater if NMC is initiated before rather than at or after 9 months of age. Maternal education was used as a proxy variable for children's risk status because it is the most robust and reliably measured predictor of PA across studies[5-9,25] and because it has practical value in the context of service delivery.

METHODS

SUBJECTS

A sample of 1759 infants representative of children born in the province of Québec (Canada) from 1997 through 1998 were selected through birth registries and followed up annually from 5 to 60 months of age. Yearly home interviews were conducted with the mothers to obtain information about family, parent, and child characteristics and behaviors. Informed written consent was obtained from all participants. Approval of the study was obtained by the Québec Institute of Statistics' institutional review board. Multivariate analyses were conducted on the 1691 children (96.1%) for whom complete data were available. All analyses were weighted to ensure the representativeness of the sample. **Table 1** describes the demographic characteristics of the sample.

MEASURES

The main outcome variable evaluated was children's PA at 17, 30, 42, 54, and 60 months. Mothers were asked to rate their child on a frequency scale indicating whether the child never (coded as 0), sometimes (coded as 1), or often (coded as 2) exhibits PA. The following items were included in the PA scale: hits, bites, kicks; fights; and bullies others. Scores ranged from 0 to 6. These items were also used in previous studies.[5,8,19] The internal consistency of mothers' PA ratings was assessed over time (17-60 months) ($\alpha = 0.83$) because the outcome measure included all 5 assessments of PA.

PREDICTOR VARIABLES

Coding is indicated in parentheses for each categorical variable. The NMC variable distinguished among children who initiated NMC at different time points between 3 and 31 months of age. Age cutoffs were established with reference to the age of the children at the different data collection points: before 9 months of age for time 1 (age range, 3-8 months), before 20 months for time 2 (age range, 16-19 months), and before 32 months for time 3 (age range, 27-31 months). Most children received NMC in family day care settings outside the home, either by nonrelatives (40.7%) or relatives (30.9%). Fifteen percent received NMC in center-based settings. The remaining (13.6%) received NMC in various other settings. We computed a variable for the mean number of hours in NMC that reflected the mean number of hours in NMC services across the entire preschool period.

Maternal education was treated as a dummy variable indicating if the mother had a high school diploma (0) or not (1).

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

POTENTIAL CONFOUNDING FACTORS (SOCIAL SELECTION FACTORS)

Four categories of variables were examined as potential confounds. Associations between the predictor variables and the outcome were examined and some variables were categorized to reflect the best risk cutoff.

Maternal Characteristics and Maternal Behavior

Age of the mother was treated as a dummy variable reflecting 21 years or younger at the birth of the target child (0) or older than 21 years (1). Becoming a mother before age 21 years was shown to be a valid indicator of risk in the Quebec population.[9]

Maternal antisocial behaviors before the end of high school were assessed via a questionnaire to the mothers, inquiring whether they had exhibited 5 conduct problems (eg, having been in more than 1 fight that they started or had stolen more than once).[31] The number of symptom counts was used in the analyses.

Maternal depression was assessed through a lifetime depression section modified from the Diagnostic Interview Schedule.[32,33] Mothers who reported having had at least 1 major depressive episode during their lifetime (1) were distinguished from those who did not (0). The maximum number of drinks in 1 occasion (at first assessment) was also examined as a potential confound. Finally, *maternal work* reflected whether the mother was working or studying (0) or not (1) at first assessment.

Child Characteristics

The sex of the child was coded as 0 for girls and 1 for boys. *Child temperament* was rated by the mother using 7 items from the difficult temperament scale of the Infant Characteristics Questionnaire.[34] Each item (for example, how often the child was difficult to calm or soothe or was fussy and if the child was easily upset) ranged from 1 to 7. Internal consistency coefficient (α) was 0.84. The child's race was coded as white (0) or other (1). Information on the birth of the child was obtained from hospital records and coded as preterm (1) if the child was born before the 37th week of gestation or on time (0) if the child was born at or after 37 weeks' gestation. Low birth-weight was coded as yes (1) if the infant weighed 2500 g or less or no (0) if the infant weighed more than 2500 g. Information on the health of the child was obtained through a question to the mother inquiring whether her child's health at birth was good (0) or poor (1).

Family Demographics 5 Months After Birth

Insufficient household income was calculated using Statistics Canada on the basis of the family annual income, the number of people in the household, and the family zone of residence (urban vs rural based on population density). Income was coded as sufficient (0) or not sufficient (1). *Family situation* was coded according to whether the parents were married or living together (0); separated, divorced, or widowed (1); or the mother has always been single (2). *Number of children in the family* was coded according to the presence (1) or absence (0) of siblings.

Family Processes 5 Months After Birth

Family functioning was assessed with an 8-item scale measuring how well the family functioned (eg, there are lots of bad feelings in our family; $\alpha = 0.97$),[35] with higher values indicative of dysfunction in the family.

Mothers completed a questionnaire on parenting perceptions and behaviors.[36] Mothers answered using a scale of 0 ("not at all what I think or did") to 10 ("exactly what I think or did"). The following 4 dimensions reflected the quality of mothers' interactions with their 5-month-old infant: self-efficacy, parental impact, coercive parenting, and overprotection. Internal consistency coefficients (α) were 0.70, 0.69, 0.62, and 0.58, respectively.

ANALYSES

The analyses were conducted in 3 steps: identification of an atypically elevated trajectory of PA, identification of variables that could potentially confound the association between NMC and PA, and testing the modifying role of NMC.

IDENTIFYING AN ATYPICALLY ELEVATED TRAJECTORY OF PA

Following previous studies,[5,8,19] distinctive clusters of developmental trajectories were identified using a semiparametric mixture model described by Broidy et al[37] and Nagin.[38] The model selection was based on the Bayesian information criterion. Models with 1 to 6 groups were estimated. The model that minimized the Bayesian information criterion was chosen. The procedure yields 2 outcomes: (1) the probability of membership in the high PA trajectory, which is a continuous measure, ranging from 0 to 1 and (2) actual membership in the high PA trajectory, derived from assignment to the high PA trajectory (coded as 1) or to another trajectory (coded as 0).

IDENTIFYING CONFOUNDING FACTORS

We tested the bivariate associations between several family and child risk variables and (1) age at initiation of NMC and (2) the probability of membership in the high PA trajectory and controlled for the variables associated with both NMC and PA.

TESTING THE MODIFYING ROLE OF NMC

Multiple regression analyses were conducted with the probability of belonging to a high trajectory of PA as the outcome. The predictors were entered in a stepwise fashion in the following order: (1) the identified confounder variables, (2) the main effect of maternal education and NMC, and (3) the interaction between timing of NMC and maternal education. Different cutoffs were considered with regard to the timing of the NMC variable. The same model was tested using logistic regression with membership in the high PA trajectory as the outcome.

RESULTS

IDENTIFYING AN ATYPICALLY ELEVATED TRAJECTORY OF PA

The best trajectory model comprised 3 groups. Seventeen percent of children were estimated to belong to the high PA trajectory group. These children were atypical in that they represented a small group of children with clearly higher levels of PA during early childhood (between 17 and 60 months). **Figure 1** illustrates the trajectory model.

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

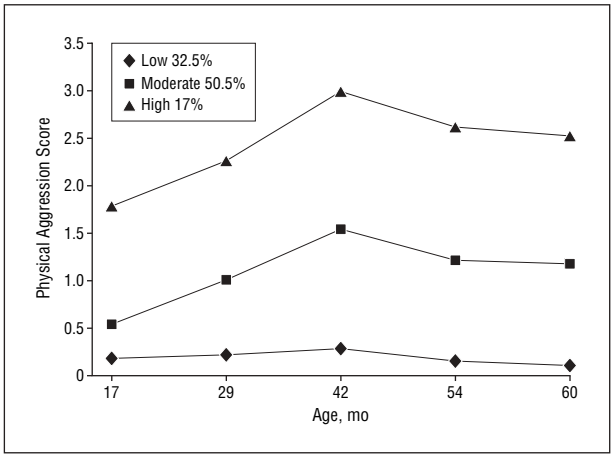

Figure 1. Trajectories of physical aggression between age 17 and 60 months (n=1758).

IDENTIFYING CONFOUNDING FACTORS

Among the factors for which we tested the associations between NMC and the high PA trajectory, 5 variables were found to be significantly associated with both NMC and PA: the presence of siblings, insufficient income, maternal depression, maternal work, and family status. These variables were used as controls in the analyses. **Table 2** presents the associations among NMC, the high PA trajectory, and the potential confounding variables.

THE MODIFYING ROLE OF NMC

Table 3 presents the results of the multiple regression analysis that examined the association among NMC, maternal education, and PA. Entering the confounding variables in step 1 revealed significant associations for all variables. Step 2 revealed a significant main effect of maternal education but not of NMC. Step 3 revealed a significant interaction between timing of NMC, as defined by the cutoff of 9 months, and maternal education. **Figure 2** illustrates the interaction. All subsequent analyses used the "before 9 months" vs "at or after 9 months" cutoff.

Follow-up analyses were conducted to test the differences between the interaction groups. Cohen's *d* effect sizes were calculated according to the following equation[39]:

$$d = (X_{NMC} - X_{MC})/S \text{ pooled},$$

where

$$S \text{ pooled} = \sqrt{\{[(n_{NMC}{}^{-1})(s_{NMC}{}^{2}) + (n_{MC}{}^{-1})(s_{MC}{}^{2})]/(n_{NMC} + n_{MC}{}^{-2})\}}.$$

(S is the pooled standard deviations of the maternal care (MC) and NMC groups; x, mean; n, number of subjects; and s, standard deviation of each group.) Negative *d*s reflect that NMC is associated with a lower probability of high PA.

These analyses revealed 3 main findings. First, children of mothers with low levels of education were at significantly lower risk of high PA if they received NMC before 9 months (n=39; mean, 0.14; SD, 0.31) or after 9 months (n=221; mean, 0.23; SD, 0.36) compared with those who never received NMC (n=36; mean, 0.36; SD, 0.40). The effect size was large for NMC initiated before 9 months (d=–0.62; SD, 0.24; 95% confidence interval [CI], –1.09 to –0.16) and moderate for NMC initiated at or after 9 months (d=–0.37; SD, 0.18; 95% CI, –0.73 to –0.02). Second, children of mothers who graduated from high school were not at higher risk for PA if they received NMC, whether it was initiated before 9 months (n=196; mean, 0.18; SD, 0.30) or at or after 9 months (n=1125; mean, 0.17; SD, 0.31) compared with those who never received NMC (n=75; mean, 0.15; SD, 0.30).

We tested the same model using logistic regression and membership in the high trajectory of PA (compared with any of the other 2 trajectory groups) as the outcome. We obtained the same pattern of results. Children of mothers with low education levels who received NMC before 9 months were less likely to belong to the high PA trajectory (odds ratio [OR], 0.20; 95% CI, 0.05-0.90) compared with children who never received NMC. Children of mothers with low education levels who received NMC at or after 9 months were also less likely to belong to the high PA trajectory than those who never received NMC (OR, 0.36; 95% CI, 0.13-1.04), but the effect was only marginally significant (P=.06).

ADDITIONAL ANALYSES AND RESULTS

We conducted additional analyses to examine whether the amount of time spent in NMC could account for the pattern of findings. Introducing a variable reflecting the mean number of hours in NMC did not modify the pattern of results. The variable is not included in the final model (Table 3), because it was not significantly associated with the outcome (β=.05, SD, 1.85; P=.07). We also conducted additional analyses to examine whether the children of the high PA trajectory group who benefited from early NMC were deflected to the medium or the low PA trajectory group. To do so, we tested the same model comparing different trajectory groups. We found the same interaction effect for the model comparing membership in the high vs medium trajectory, but not in the model opposing the high vs low trajectory groups. This result indicates that children of the high trajectory group benefiting from early NMC were deflected to the medium trajectory (and not the low trajectory) group. Finally, we tested all the 3-way interactions among the predictors using a backward regression procedure. None of the 3-way interactions were significant.

COMMENT

The objectives of the study were to test, at the population level, whether NMC services can prevent early childhood PA problems and whether the protective role is a function of the age at which NMC services are initiated. We found, using multiple regression, that NMC reduced the risk of following an atypically elevated trajectory of PA among children of mothers with low education levels. The effect size was large if NMC was initiated before 9 months (d=–0.62) and moderate if initiated at or after 9 months (d=–0.37). Nonmaternal care was not associated with an increase in the risk of PA among children of better-educated mothers even if it was initiated

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

Table 2. Bivariate Associations Between Potential Confounders, PA, and Timing of NMC

	Probability of High PA Trajectory[a]	*P* Value	Timing of NMC[b,c]			
			Never (n=111)	After 9 mo (n=1346)	At or Before 9 mo (n=234)	*P* Value
Sex[b]						
Females	0.13 (0.27)	<.001	55 (49.5)	674 (50.1)	115 (49.1)	.96
Males	0.23 (0.36)		56 (50.5)	672 (49.9)	119 (50.9)	
Ethnicity (n=1677)						
Nonwhite	0.18 (0.32)	.73	33 (30.0)	422 (31.4)	76 (32.5)	.84
White	0.18 (0.32)		77 (70.0)	915 (68.0)	154 (65.8)	
Child health at birth						
Poor	0.38 (0.45)	<.05	0	9 (0.7)	1 (0.4)	.58
Good	0.18 (0.32)		111 (100.0)	1336 (99.3)	234 (100.0)	
Premature birth						
Yes	0.18 (0.34)	.96	8 (7.2)	78 (5.8)	17 (7.3)	.60
No	0.18 (0.32)		103 (92.8)	1268 (94.2)	217 (92.7)	
Low birth weight						
Yes	0.15 (0.27)	.49	7 (6.3)	14 (1.0)	49 (20.9)	<.05
No	0.17 (0.31)		106 (95.5)	1344 (96.5)	227 (16.9)	
Maternal education						
No high school diploma	0.23 (0.36)	<.05	36 (32.4)	221 (16.4)	39 (16.7)	<.001
High school diploma	0.17 (0.31)		75 (67.6)	1124 (83.5)	196 (83.8)	
Age at childbearing, y						
≤21	0.17 (0.31)	.47	9 (8.1)	146 (10.8)	39 (16.7)	<.05
>21	0.18 (0.32)		102 (91.9)	1200 (89.2)	195 (83.3)	
Maternal depression						
Yes	0.23 (0.35)	<.001	34 (30.6)	296 (22.0)	42 (17.9)	<.05
No	0.17 (0.31)		77 (69.4)	1050 (78.0)	192 (82.1)	
Maternal work before 9 mo						
Yes	0.16 (0.30)	<.001	28 (25.2)	952 (70.7)	230 (98.3)	<.001
No	0.23 (0.35)		83 (74.8)	394 (29.3)	4 (1.7)	
Presence of siblings						
Yes	0.25 (0.36)	<.001	88 (79.3)	759 (56.4)	125 (53.4)	<.001
No	0.09 (0.23)		23 (20.7)	587 (43.6)	109 (46.6)	
Insufficient income						
No	0.16 (0.30)	<.001	56 (50.5)	1006 (74.7)	181 (77.4)	<.001
Yes	0.22 (0.35)		55 (49.5)	340 (25.3)	53 (22.6)	
Family status[b]						
Always single	0.10 (0.23)	<.05	11 (9.9)	49 (3.6)	15 (6.4)	<.05
Separated, divorced, widowed	0.23 (0.37)		4 (3.6)	55 (4.1)	6 (2.6)	
Married or common-law union	0.18 (0.32)		96 (86.5)	1242 (92.3)	213 (91.0)	
Maternal conduct problems (n=1639)[d]	0.09	<.001	0.72 (0.78)[a]	0.84 (0.95)[a]	0.77 (0.97)[a]	.26
Maternal alcohol consumption[e]	0.08	<.001	0.79 (2.10)[a]	0.93 (2.76)[a]	1.33 (2.83)[a]	.08
Difficult temperament	0.03	.10	2.53 (1.55)[a]	2.75 (1.65)[a]	2.58 (1.47)[a]	.16
Age at which infant stopped breastfeeding, mo	−0.04	.10	4.33 (5.39)[a]	4.12 (4.74)[a]	3.05 (4.06)[a]	<.05
Family dysfunction (n=1678)	0.10	<.001	1.93 (1.41)[a]	1.76 (1.45)[a]	1.63 (1.51)[a]	.19
Coercive parenting (n=1636)	0.04	.08	1.07 (1.37)[a]	1.08 (1.47)[a]	1.11 (1.50)[a]	.95
Parental self-efficacy (n=1634)	−0.09	<.001	8.93 (1.26)[a]	8.75 (1.14)[a]	8.77 (1.11)[a]	.35
Perception of parental impact (n=1646)	−0.01	.77	7.82 (2.49)[a]	8.25 (1.99)[a]	8.62 (1.68)[a]	<.05
Parental overprotection (n=1652)	−0.04	.16	6.05 (2.33)[a]	5.53 (2.43)[a]	4.74 (2.27)[a]	<.001

Abbreviations: NMC, nonmaternal care; PA, physical aggression.
[a] Data are presented as mean (SD) and *r*.
[b] N=1691 unless otherwise indicated.
[c] Data are presented as number (percentage) unless otherwise indicated.
[d] Before the end of high school.
[e] Maximum number of drinks in one occasion at time 1 (5 mo).

before age 9 months. The same pattern of results emerged with logistic regression, indicating a protective effect of NMC, especially when initiated before age 9 months (OR, 0.20; 95% CI, 0.05-0.90).

The protective effect of NMC is consistent with the results of experimental studies showing long-term reduction of poor outcomes in children of mothers with low education levels who received high-quality child care services during the preschool years.[14,26] One of these experimental studies[26] did show an impressive reduction in antisocial behavior during adolescence and early adulthood, but did not document the effects on early development of aggression, as in the present study. The results are also in line with previous correlational studies showing a protective effect for children from high-risk families,[21,28] as well as with adoption studies showing that cross-fostering of high-risk chil-

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

Table 3. Stepwise Multiple Regression Predicting Physical Aggression With Maternal Education and NMC

	Model 1			Model 2			Model 3		
	B	SE (B)	β	B	SE (B)	β	B	SE (B)	β
Step 1: Control variables (R^2_{aj} = 0.077)									
Presence of siblings	0.158[a]	0.015	0.246	0.158[a]	0.015	0.246	0.158[a]	0.015	0.245
Maternal depression	0.059[a]	0.018	0.076	0.059[a]	0.018	0.077	0.056[b]	0.018	0.073
Insufficient income	0.062[a]	0.018	0.086	0.052[b]	0.019	0.073	0.053[b]	0.019	0.073
Family status[c]	0.057	0.029	0.050	0.067[b]	0.030	0.058	0.069[b]	0.030	0.059
Step 2: Main effects (R^2_{aj} = 0. 080)									
Low maternal education				0.048	0.021	0.057	0.187[b]	0.063	0.223
NMC before 9 mo[d]				0.016	0.036	0.018	0.070	0.042	0.077
NMC at or after 9 mo				0.016	0.031	0.020	0.062	0.037	0.078
Step 3: Interaction (R^2_{aj} = 0.083)									
NMC before 9 mo × low maternal education							−0.198[b]	0.082	−0.093
NMC at or after 9 mo × low maternal education							−0.147[b]	0.066	−0.155

Abbreviations: B, standardized beta coefficient; β, unstandardized beta coefficient; NMC, nonmaternal care; R^2_{aj}, how much variation is being explained by the predictor variables.

[a] $P < .001$.

[b] $P < .05$.

[c] Coded as 0 (married or common-law union) or 1 (separated or always single).

[d] Coded as 0 (never in NMC), 1 (NMC before age 9 mo), or 2 (NMC at or after 9 mo).

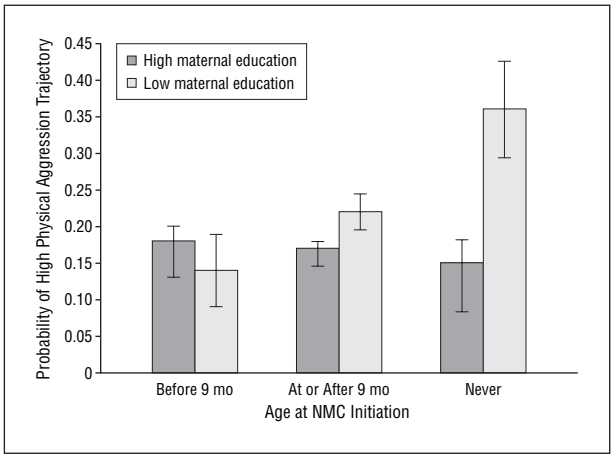

Figure 2. Interaction between maternal education and timing of nonmaternal care (NMC) initiation in predicting the high physical aggression trajectory (n=1691).

dren (low socioeconomic status) to low-risk families (high socioeconomic status) can have beneficial effects on cognitive functioning[40] and criminality.[41] However, to our knowledge, the present study is the first to use a representative sample of the population and show that NMC services initiated early in life and widely available to communities have a substantial protective effect on the long-term development of PA problems.

The study also replicates previous findings showing that family characteristics are generally stronger determinants of PA problems than NMC.[5,8,19] However, we show that NMC can make an important difference in the lives of children of mothers with low levels of education. Because these children were less likely than children of better-educated mothers to receive NMC services, special attention needs to be paid to the provision of NMC services to those most in need.

The differences associated with the timing of NMC services is an important finding. For children of mothers with low education levels who received NMC, the benefits were more important if NMC services began before age 9 months. Indeed, results from both logistic regression (OR) and multiple regression (*d*) analyses concur in showing that early NMC may almost double the beneficial effects. At least 2 hypotheses may explain the positive impact. First, children of mothers with low education levels who receive early NMC are likely to have reduced exposure to family risks (correlated with low education) at an important developmental period. Such reduced exposure may in itself be protective. Second, children in a high-risk family environment who receive early NMC may be exposed to care and early learning experiences that are of superior quality than those received at home. It is important to note, however, that mothers with low education are a heterogeneous group. Future studies should aim at identifying children of mothers with low levels of education who may benefit more than others from NMC services. Randomized controlled trials would be the best approach to this problem and would shed light on the processes through which early NMC is protective.[14,42] The proximal mechanism may be related to the provision of positive social interactions with same-age peers at a time when PA is on a steep rise,[43,44] but it may also be because of the general quality of adult care, including cognitive stimulation and language development.[45,46]

The present study has a number of strengths: (1) a large sample size representative of a population in which risk factors for PA problems resemble those of most previous studies,[8,19,47] (2) annual assessments from early infancy to school entry, and (3) reliable and valid assessments of both child and family characteristics. However, some limitations should be noted.

First, caution is required in generalizing the findings to populations in which frequency of use of NMC differs substantially and where the quality of NMC services may be lower. The mean quality of NMC services

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

in the population of the present study is similar to that of several other industrialized countries (ie, United States, Germany, Portugal, and Spain).[30,48]

Second, the yearly data collections did not allow us to obtain more precise information about the timing of initiation of NMC. Experimental studies testing the differential impact of NMC initiated at different ages are needed to study more precisely the effect of timing of NMC.

Third, although we examined the potentially confounding effects of a wide range of factors and were careful in controlling for confounding factors, the study remains correlational and thus limits our capacity to make causal inferences. For instance, some uncontrolled adversities faced by mothers with low education who were not working (such as in cases of severe substance abuse and domestic violence) may be related to the pattern of findings.[49] However, it must be kept in mind that the results are in line with those of experimental studies, and extend these by giving a population perspective.

Fourth, we relied on mothers for assessments of child and family characteristics. The time line covered by the present study (5-60 months), in combination with the type of sample (large and representative), makes it difficult to rely on other sources of information than parents. Reliance on day care staff would also be problematic because not all children attend day care. However, results from the trajectory analyses and risk factors show clearly that they are well in line with most studies of early PA problems.[8,47] Finally, virtually all mothers (98.7%) who were using NMC services before their child was age 9 months were also working. Thus, it was not possible, with our sample, to disentangle the benefits associated with the use of NMC services from those associated with maternal work and correlated maternal competencies. This is an important issue that should be addressed in future studies.

In summary, we provide robust evidence that the provision of NMC services to children of mothers with low levels of education could substantially reduce their risk of chronic PA, and that the protective impact is more important if children begin to receive these services before age 9 months. Because the children most likely to benefit from NMC are those less likely to receive them, universal programs involving the provision of NMC should include special measures encouraging the use of NMC services among high-risk families.

Submitted for Publication: November 9, 2006; final revision received April 8, 2007; accepted April 12, 2007.
Correspondence: Sylvana M. Côté, PhD, Université de Montréal, GRIP, 3050 Edouard-Montpetit, Montréal, QC H3T 1J7, Canada (sylvana.cote@umontreal.ca).
Financial Disclosure: None reported.
Funding/Support: This research was supported by the Québec Government Ministry of Health and Fond, Québécois de la Recherche sur la Société et la Culture, Canada's Social Science and Humanities Research Council, Canadian Institutes for Health Research, St-Justine Hospital's Research Center, and the University of Montréal.
Additional Contributions: The Québec Institute of Statistics and the staff of the Groupe de Recherche sur l'Inadaptation Psychosociale chez l'Enfant (GRIP) provided data collection and management. Statistical analyses were conducted by Ms Xu under the guidance of Drs Côté and Nagin.

REFERENCES

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. Washington, DC: American Psychiatric Association; 1994.
2. Krug EG, Dahlberg LL, Mercy JA, Zwi AB, Lozano RE. World report on violence and health. World Health Organization Web site. www.who.int/violence_injury_prevention/violence/world_report/wrvh1/en. Accessed March 5, 2005.
3. Lahey BB, Loeber R, Quay HC, Applegate B, Shaffer D, Waldman I, Hart EL, McBurnett K, Frick PJ, Jensen PS, Dulcan MK, Canino G, Bird HR. Validity of DSM-IV subtypes of conduct disorder based on age of onset. *J Am Acad Child Adolesc Psychiatry*. 1998;37(4):435-442.
4. McCord J, Widom CS, Crowell NE. *Juvenile Crime, Juvenile Justice*. Washington, DC: National Academy Press; 2001.
5. Côté SM, Vaillancourt T, LeBlanc JC, Nagin DS, Tremblay RE. The development of physical aggression from toddlerhood to pre-adolescence: a nation wide longitudinal study of Canadian children. *J Abnorm Child Psychol*. 2006;34(1):71-85.
6. Nagin DS, Tremblay RE. Analyzing developmental trajectories of distinct but related behaviors: a group-based method. *Psychol Methods*. 2001;6(1):18-34.
7. Nagin DS, Tremblay RE. Parental and early childhood predictors of persistent physical aggression in boys from kindergarten to high school. *Arch Gen Psychiatry*. 2001;58(4):389-394.
8. National Institute of Child Health and Human Development. *Trajectories of Physical Aggression From Toddlerhood to Middle School: Monographs of the Society for Research in Child Development*. Malden, MA: Blackwell Publishing Inc; 2004. Monograph 278 69-4.
9. Tremblay RE, Nagin DS, Séguin JR, Zoccolillo M, Zelazo PD, Boivin M, Pérusse D, Japel C. Physical aggression during early childhood: trajectories and predictors. *Pediatrics*. 2004;114(1):e43-e50. http://pediatrics.aapublications.org/cgi/content/full/114/1/e43. Accessed December 3, 2004.
10. Kippin TE, Cain SW, Masum Z, Ralph MR. Neural stem cells show bidirectional experience-dependent plasticity in the perinatal mammalian brain. *J Neurosci*. 2004;24(11):2832-2836.
11. Lupie SJ, King S, Meaney MJ, McEwen BS. Can poverty get under your skin? basal cortisol levels and cognitive function in children from low and high socioeconomic status. *Dev Psychopathol*. 2001;13(3):653-676.
12. Suomi SJ. Social and biological mechanisms underlying impulsive aggressiveness in rhesus monkeys. In: Lahey BB, Moffitt TE, Caspi A, eds. *Causes of Conduct Disorder and Juvenile Delinquency*. New York, NY: Guilford Press; 2003: 345-362.
13. Weaver ICG, Cervoni N, Champagne FA, D'Alessio AC, Sharma S, Seckl JR, Dymov S, Szyf M, Meaney MJ. Epigenetic programming by maternal behavior. *Nat Neurosci*. 2004;7(8):847-854.
14. Campbell FA, Ramey CT, Pungello EP, Sparling J, Miller-Johnson S. Early childhood education: young adult outcomes from the Abecedarian Project. *Appl Dev Sci*. 2002;6(1):42-57. doi:10.1207/S1532480XADS0601_05.
15. Campbell TS, Ditto B, Séguin JR, Assaad JM, Pihl RO, Nagin D, Tremblay RE. A longitudinal study of pain sensitivity and blood pressure in adolescent boys. *Health Psychol*. 2002;21(6):594-600.
16. Waldfogel J, Han WJ, Brooks-Gunn J. The effects of early maternal employment on child cognitive development. *Demography*. 2002;39(2):369-392.
17. Statistics Canada Web site. http//www.statcan.ca/Daily/English/050207/d050207b.htm. Accessed May 5, 2005.
18. NICHD Early Child Care Research Network. *Child Care and Child Development: Results From NICHD Early Child Care Research Network*. National Institute of Child Health and Human Development, ed. New York, NY: Guilford Press; 2005.
19. Borge AI, Rutter M, Côté S, Tremblay RE. Early childcare and physical aggression: differentiating social selection and social causation. *J Child Psychol Psychiatry*. 2004;45(2):367-376.
20. Jackson AP. Maternal self-efficacy and children's influence on stress and parenting among single black mothers in poverty. *J Fam Issues*. 2000;21(1):3-16. doi: 10.1177/019251300021001001.
21. DeGarmo DS, Forgatch M, Martinez C Jr. Parenting of divorced mothers as a link between social status and boy's academic outcomes: unpacking the effects of socioeconomic status. *Child Dev*. 1999;70(5):1231-1245.
22. Luo ZC, Wilkins R, Kramer MS; Fetal and Infant Health Study Group of the Canadian Perinatal Surveillance System. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. *CMAJ*. 2006; 174(10):1415-1420.

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017

23. Shonkoff JP, Phillips DA, eds. *From Neurons to Neighborhoods: The Science of Early Child Development.* Washington, DC: National Academy Press; 2000.
24. Geoffroy MC, Côté SM, Borge AI, Larouche F, Séguin JR, Rutter M. Association between nonmaternal care in the first year of life and children's receptive language skills prior to school entry: the moderating role of the socioeconomic status. *J Child Psychol Psychiatry.* 2007;48(5):490-497.
25. Barker ED, Tremblay RE, Nagin DS, Vitaro F, Lacourse E. Development of male proactive and reactive physical aggression during adolescence. *J Child Psychol Psychiatry.* 2006;47(8):783-790.
26. Caughy MOB, DiPietro JA, Strobino DM. Day-care participation as a protective factor in the cognitive development of low-income children. *Child Dev.* 1994; 65(2 Spec No):457-471.
27. Schweinhart LJ, Weikart DP. The high/scope preschool curriculum comparison study through age 23. *Early Child Res Q.* 1997;12(2):117-143.
28. National Institute of Child Health and Human Development. Does amount of time spent in child care predict socioemotional adjustment during the transition to kindergarten? *Child Dev.* 2003;74(4):976-1005.
29. Egeland B, Heister M. The long-term consequences of infant day-care and mother-infant attachment. *Child Dev.* 1995;66(2):474-485.
30. Japel C, Tremblay RE, Côté S. The quality of the services to the early childhood: results of the longitudinal study on the development of the children of Quebec (ELDEQ) [in French]. *Éducation et Francophonie.* 2005;23(2):7-27.
31. Zoccolillo M, Paquette D, Azar R, Côté S, Tremblay RE. Parenting as an important outcome of conduct disorder in girls. In: Putallaz M, Bierman KL, eds. *Aggression, Antisocial Behavior and Violence Among Girls: A Developmental Perspective.* New York, NY: Guilford Press; 2004:241-261.
32. Robins LN. *Diagnostic Interview Schedule for the DSM-IV.* St Louis, MO: Dept of Psychiatry, Washington University; 2003.
33. Roy CA, Zoccolillo M, Gruber R, Boivin M, Perusse D, Tremblay RE. Construct validity of an instrument to assess major depression in parents in epidemiologic studies. *Can J Psychiatry.* 2005;50(12):784-791.
34. Bates JE, Freeland C, Lounsbury ML. Measurement of infant difficultness. *Child Dev.* 1979;50(3):794-803.
35. Boyle MH, Offord DR, Hofmann HG, Catlin GP, Byles JA, Cadman DT, Crawford JW, Links PS, Rae-Grant NI, Szatmari P. Ontario child care study, I: methodology. *Arch Gen Psychiatry.* 1987;44(9):826-831.
36. Boivin M, Pérusse D, Dionne G, Saysset V, Zoccolillo M, Tarabulsy GM, Tremblay N, Tremblay RE. The genetic-environmental etiology of parents' perceptions and self-assessed behaviours toward their 5-month-old infants in a large twin and singleton sample. *J Child Psychol Psychiatry.* 2005;46(6):612-630.
37. Broidy LM, Nagin DS, Tremblay RE, Bates JE, Brame B, Dodge KA, Fergusson D, Horwood JL, Loeber R, Laird R, Lynam DR, Moffitt TE, Pettit GS, Vitaro F. Developmental trajectories of childhood disruptive behaviors and adolescent delinquency: a six-site, cross-national study. *Dev Psychol.* 2003;39(2):222-245.
38. Nagin DS. *Group-Based Modeling of Development Over the Life Course.* Cambridge, MA: Harvard University Press; 2005.
39. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* 2nd ed. Hillsdale, NJ: Lawrence Erlbaum; 1988.
40. Capron C, Duyme M. Assessment of effects of socioeconomic status on an I.Q. in a full cross-fostering study. *Nature.* 1989;340(6234):552-554. doi:10.1038/340552a0.
41. Van Dusen KT, Mednick SA, Gabrielli W. Prospective studies of crime and delinquency. In: Van Dusen KT, Mednick SA, eds. *Social Class and Crime in an Adoption Cohort.* Boston, MA: Kluwer-Nijhoff Publishing; 1983:127-137.
42. McCormick MC, Brooks-Gunn J, Buka SL, Goldman J, Yu J, Salganik M, Scott DT, Bennett FC, Kay LL, Bernbaum JC, Bauer CR, Martin C, Woods ER, Martin A, Casey PH. Early intervention in low birth weight premature infants: results at 18 years of age for the Infant Health and Development Program. *Pediatrics.* 2006; 117(3):771-780.
43. Alink LRA, van Zeijl J, Stolk MN, Stolk MN, Juffer F, Koot HM, Bakermans-Kranenburg MJ, van Ijzendoorn MH, et al. The early childhood aggression curve: development of physical aggression in 10- to 50-month-old children. *Child Dev.* 2006;77(4):954-966.
44. Tremblay RE. The development of human physical aggression: how important is early childhood? In: Leavitt LA, Hall DMB, eds. *Social and Moral Development: Emerging Evidence on the Toddler Years.* New Brunswick, NJ: Johnson and Johnson Pediatric Institute; 2004:221-238.
45. Dionne G, Tremblay RE, Boivin M, Laplante D, Pérusse D. Physical aggression and expressive vocabulary in 19-month-old twins. *Dev Psychol.* 2003;39(2): 261-273.
46. Stattin H, Klackenberg-Larsson I. Early language and intelligence development and their relationship to future criminal behavior. *J Abnorm Psychol.* 1993; 102(3):369-378.
47. Keenan K, Wakschlag LS. More than the terrible twos: the nature and severity of behavior problems in clinic-referred preschool children. *J Abnorm Child Psychol.* 2000;28(1):33-46.
48. Cryer D, Tietze W, Burchinal M, Leal T, Palacios J. *Predicting Process Quality From Structural Quality in Preschool Programs: A Cross-Country Comparison.* Chapell Hill: University of North Carolina; 1998.
49. Whitaker RC, Orzol SM, Kahn RS. Maternal mental health, substance use, and domestic violence in the year after delivery and subsequent behavior problems in children at age 3 years. *Arch Gen Psychiatry.* 2006;63(5):551-560.

©2007 American Medical Association. All rights reserved.
Downloaded From: http://archpsyc.jamanetwork.com/ on 04/30/2017