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Obstetrical Complications and Violent Delinquency: Testing Two Developmental Pathways

Louise Arseneault, Richard E. Tremblay, Bernard Boulerice, and Jean-François Saucier

This study focused on the interaction between specific obstetrical complications and early family adversity in predicting violent behavior during childhood and adolescence, in a sample of 849 boys from low socioeconomic areas of Montréal, Canada. Obstetrical complication data from medical records were used to create three scales using a nonlinear principal component analysis followed by rotation. Family adversity and teacher-rated physical aggression were assessed when the boys were in kindergarten and self-reports of delinquency were collected when they were 17. Elevated scores on the Deadly Risk Situation scale of obstetrical complications (preeclampsia, umbilical cord prolapse, and induced labor) increased the risk of being violent at both 6 and 17 years of age, only among boys who grew up in high adverse familial environments. Moreover, this interaction partly accounted for the continuity between violence in childhood and adolescence. Interventions for young pregnant women from deprived environments and their babies are discussed in light of these results.

INTRODUCTION

Individuals who experience both obstetrical complications and adverse psychosocial conditions, such as early maternal rejection or a disadvantaged familial environment, are more likely to perpetrate specifically violent crimes during adolescence and adulthood (Piquero & Tibbetts, 1999; Raine, Brennan, & Mednick, 1994, 1997). From a developmental perspective, at least two pathways could lead to such an outcome. First, the interaction between obstetrical complications and psychosocial risk factors could create a vulnerability that increases the likelihood that the challenges of adolescence, such as dealing with peer pressure or becoming acquainted with alcohol and drugs, will be met with a flurry of violent behaviors, which may or may not disappear during adulthood (Elliott, 1994; Greenwood, 1995). Alternatively, obstetrical complications and psychosocial risk factors could have an immediate impact on children's abilities to learn to control their physically aggressive behaviors. In this case, violent offending during adolescence would be the adolescent expression of chronic physical aggression that started in early childhood.

Differentiating between these two pathways is important when deciding on prevention strategies to put into place. It could be argued that interventions during the adolescent years would be sufficient to prevent the first pathway to violent delinquency. The second pathway, however, could probably be prevented only by interventions earlier in life. The present study attempted to clarify this developmental question by studying the effect of the interaction between obstetrical complications and family adversity on violent behavior during both childhood and adolescence.

Developmental Theories of Violent and Antisocial Behaviors

Two competing developmental pathways emanate from studies identifying a subgroup of individuals who get involved in antisocial activities in mid-adolescence (Haapasalo & Tremblay, 1994; Patterson, 1993; Patterson, DeBaryshe, & Ramsey, 1989), and another subgroup of individuals who show continuous disruptive behavior from childhood onward (Caspi, Henry, McGee, Moffitt, & Silva, 1995; Caspi & Silva, 1995; Moffitt, 1993; Nagin & Tremblay, 1999). In early adolescence, the "late starters" become involved with deviant peers and increase the amount of time they spend wandering the streets (Patterson et al., 1989). These behaviors could trigger an existing vulnerability toward antisocial behavior in adolescents from adverse environments who had suffered obstetrical complications. For the "life-course-persistent" antisocial individuals, antisocial behavior appears during early childhood, and persists through adulthood. Neuropsychological deficits could account for the early onset, but the interaction between those deficits and a disadvantaged environment that exacerbates these children's dysfunction could explain the persistence of antisocial behavior (Moffitt, 1993).

How Obstetrical Complications Could Influence Each Developmental Pathway

The theoretical assumption behind studies linking obstetrical risk factors and criminality is that neuro-

psychological deficits leading to behavioral problems are engendered by fetal brain damage, which may have been caused by obstetrical complications. Support for the first developmental pathway, in which antisocial behavior emerges in midadolescence, comes from studies on the etiology of schizophrenia. Findings provide strong evidence that obstetrical complications contribute to the etiology of schizophrenia (Cannon, Mednick, & Parnas, 1989; Cannon et al., 1993, 2000; O'Callaghan et al., 1995) and suggest that the effect of obstetrical complications on brain abnormalities increases the probability of schizophrenia among individuals genetically at risk (Cannon, 1997). Given that individuals with schizophreniform disorder are four to six times more likely to be violent compared with individuals without this disorder (Arseneault, Moffitt, Caspi, Taylor, & Silva, 2000; Hodgins, Mednick, Brennan, Schulsinger, & Engberg, 1996; Stueve & Link, 1997; Tiihonen, Isohanni, Räsänen, Koiranen, & Moring, 1997), obstetrical complications could similarly increase the risk of violent behavior among individuals growing up in adverse environments. In addition, given that schizophrenia is a psychiatric disorder with a late age of onset and an abrupt appearance (Cannon & Jones, 1996; Häfner, Maurer, Löffler, & Riecher-Rössler, 1993), obstetrical complications could have an impact on violent behavior that would manifest itself in late adolescence, supporting the first pathway from obstetrical complications to violent delinquency.

Support for the second pathway, in which antisocial behavior appears in an early life stage, comes from studies that link obstetrical complications (e.g., episiotomy, chronic fetal hypoxia, induction of labor, placenta problems, and umbilical cord prolapse) with neuropsychological deficits and cognitive functioning (Buka, Tsuang, & Lipsitt, 1993; O'Dwyer, 1997; Seidman et al., 2000). Given that neuropsychological deficits, such as impairments in verbal and executive functioning, are involved in persistent antisocial behavior that is rooted early in life (Moffitt, 1990; Moffitt & Henry, 1989; Séguin, Pihl, Harden, Tremblay, & Boulerice, 1995; Tremblay et al., 1999; Tremblay, Mâsse, et al., 1992; White, Moffitt, Earls, Robins, & Silva, 1990), obstetrical complications could have an impact on violent behavior that would manifest itself in the preschool years, supporting the second pathway from obstetrical complications to violent delinquency.

A recent study on delivery complications and violent behavior (Raine et al., 1997) traced a developmental pathway to violence by showing that the interaction between delivery complications and early maternal rejection held for individuals whose first offense occurred before age 18, but not for those who committed their first crime after age 18. Based on these results, one could conclude that this interaction effect was specific to early-onset but not late-onset violence. Considering Moffitt's (1993) theoretical perspective—that chronic antisocial behavior starts early in life—as well as results from longitudinal studies (Tremblay, Mâsse, et al., 1992; White et al., 1990) that have shown the stability of childhood disruptive behaviors, one would expect that violent individuals who suffered from both obstetrical complications and early adverse psychosocial factors would have a history of violent behavior starting in early childhood. Moreover, one would expect that this interaction would partly account for the risk of violence during adolescence among physically aggressive children. The present study was designed to test whether the interaction between obstetrical complications and familial adversity also predicts childhood physical aggression, and whether it accounts for the continuity of violent behavior from childhood to adolescence, in a sample of young boys for which data were available from birth to adolescence.

Limits of Previous Studies

Two limitations have characterized studies on the links between obstetrical complications and antisocial behavior. First, studies have used official records of criminal behavior (Brennan, Mednick, & Kandel, 1991; Kandel & Mednick, 1991; Piquero & Tibbetts, 1999; Raine et al., 1994, 1997). Official records are known to underestimate delinquent activity because many offenses are not reported or are not treated by the justice system (Elliott, 1994; Elliott, Huizinga, & Morse, 1986). Thus, the association between obstetrical complications and violent behavior in the general population may be underestimated by previous studies or may be specific to convicted criminals. The present study attempted to overcome this limitation by using self-reports of delinquency, which have been shown to be a valuable tool in crime and delinquency research (Junger-Tas & Marshall, 1999).

Second, measures of obstetrical complications tend to be nonspecific (see Zornberg, Buka, & Tsuang, 2000a). One type of measure is a variety score, which is the sum of the total number of different obstetrical complications experienced during delivery, and is often dichotomized subsequently. The severity of the complications is not taken into account by this scoring system, and when the scores are dichotomized the information is reduced to indicate only those individuals who experienced at least one complication during their birth. This type of measure is not useful to examine how obstetrical complications can lead to be-

havioral outcome. A second type of measure is a severity score based on weighted scores, as determined by obstetricians or pediatricians. These scores could be biased by each clinician's own clinical experience, however. A recent study (McNeil, Cantor-Graae, & Sjöström, 1994) showed that the type of scale used to quantify birth complication data has a considerable impact on results, but no scoring system has yet been proven to statistically quantify and cluster obstetrical complications based on their severity and the extent to which they covary (Dalman, Allebeck, Cullberg, Grunewald, & Köster, 1999; McNeil et al., 1994). To address this methodological limitation, a nonlinear principal component analysis followed by rotation was used in the present study to quantify and group obstetrical complications.

Goal of the Present Study

The main aim of the present study was to test the interaction between obstetrical complications and family adversity on both childhood and adolescent violent behavior. Obstetrical complication data were first quantified and scaled based on their frequency and their covariance. Second, using age 17 self-reported violent delinquency as an outcome, we tested whether the interaction between obstetrical complications and family adversity predicted violent delinquency. Third, we examined whether the interaction predicted teacher-rated physical aggression during the boys' kindergarten years. Fourth, we tested whether the interaction between obstetrical complications and family adversity explained the continuity of violent behavior between ages 6 and 17. Fifth, we tested whether the effects found were specific to violent delinquency (as opposed to nonviolent delinquency) as suggested by theories of antisocial behaviors (Moffitt, 1993) and empirical results (Piquero & Tibbetts, 1999; Raine et al., 1994).

METHOD

Sample

Participants were part of an ongoing longitudinal study (Tremblay, Pihl, Vitaro, & Dobkin, 1994) that started during their kindergarten years. Kindergarten teachers from 53 schools in low socioeconomic areas of Montréal, Canada, were asked to rate the behavior of each boy in their class. Questionnaires were completed for a total of 1,161 boys. To create a culturally homogeneous group, only White boys whose native language was French and whose mother and father were born in Canada were included in the sample (N = 1,037, 89%). Because all participants were recruited in regular schools, none had any mental retardation or significant physical handicaps. Complete data files for behaviors from kindergarten to adolescence were available for 849 boys (81.9%). Participants who were not included in the analyses of delinquency because of missing data (n = 188) tended to be more aggressive, anxious, inattentive, hyperactive, and less prosocial at age 6, than the rest of the sample (Table 1); their parents tended to be less educated; and their mothers tended to have lower occupational prestige.

Table 1 Differences between Subjects Included in the Analyses and Those Not Included Relative to Age 6 Teacher-Rated Behaviors and Socioeconomic Variables

	Subjects Included in Analyses[a]		Subjects Not Included in Analyses[b]		
	M	*SD*	*M*	*SD*	*t*
Age 6 behaviors					
Physical aggression	1.35	1.72	1.65	1.88	2.02*
Hyperactivity	1.35	1.42	1.60	1.56	2.01*
Anxiety	2.30	2.25	2.79	2.53	2.46*
Inattention	2.56	2.27	3.15	2.49	2.94**
Prosociality	8.13	5.05	7.36	4.45	2.09*
Socioeconomic variables					
Mother's age at birth of first child	23.27	4.02	23.41	4.75	.35
Father's age at birth of first child	26.39	4.94	26.25	5.64	.27
Mother's education level	10.59	2.82	10.00	2.62	2.64**
Father's education level	10.68	3.35	10.09	3.05	2.13*
Mother's occupational prestige	38.72	12.10	35.96	11.85	2.51*
Father's occupational prestige	39.66	13.04	38.28	11.81	1.22

Note: *N*s may slightly vary across socieconomic variables and behaviors at age 6.
[a] $N = 849$.
[b] $N = 188$.
* $p < .05$; ** $p < .01$.

Instruments

Obstetrical complications. Information on obstetrical complications was collected by consulting hospital medical records. Based on Kandel and Mednick's results (1991) that showed that delivery complications, but not pregnancy events, predicted violent convictions, only the former were considered in this study. (Minor physical anomalies—indicators of pregnancy complications—in relation to adolescent

delinquency were examined in the published study by Arseneault, Tremblay, Boulerice, Séguin, and Saucier, 2000.) Delivery complications included umbilical cord prolapse, preeclampsia, fetal distress, hypoxia, cephalo-pelvic disproportion, and irregular position of the fetus. Medical interventions were also studied and were interpreted as indices of the seriousness of the delivery complications. These included induced labor, anesthesia, use of forceps, medications, episiotomy, and cesarean section. Other obstetrical complications were examined but could not be included in the analyses because of extremely low base rates (e.g., long birth duration). When a specific complication was not mentioned in the medical records, it was coded as if it had not occurred (ranging from 1.6% of cases for less severe interventions such as episiotomy, to 24.5% for more severe complications such as preeclampsia). Only participants with complete data on the 12 obstetrical variables were included in the nonlinear principal component analysis ($n = 831$). Participants not included in subsequent analyses on delinquency because of missing data during adolescence had similar proportions of obstetrical complications as compared with those included in the analyses.

The total sample frequency, which is a measure of rarity, was used as an indicator of the severity of obstetrical complications (Table 2): the more frequent a complication, the less dangerous it might be for the fetus. When a complication occurs frequently, medical staff are more likely to know how to handle the situation rapidly, thus limiting its impact on the newborn. The more rare a complication, the more likely that medical science has not discovered how to reduce its adverse effect on the fetus. In addition, rare combinations of birth complications and medical interventions could indicate the severity of a situation. Rare complications and rare combinations have a greater probability of inflicting physical damage or neuropsychological deficits on the newborn.

Familial adversity. Seven socioeconomic indices were used to create an index of family adversity (Tremblay et al., 1991). These indices were: mother's and father's occupational prestige, mother's and father's age at birth of their first child, mother's and father's education level, and familial status. Information on these indices was collected during a telephone interview with the mother at the end of the boy's kindergarten year. Occupational prestige represents a

Table 2 Percentages and Counts of Medical Interventions Relative to Delivery Complications

	Medical Interventions											
	Induced Labor ($N = 72$)		Anesthesia ($N = 723$)		Forceps ($N = 178$)		Medications ($N = 581$)		Episiotomy ($N = 588$)		C-Section ($N = 111$)	
Delivery Complications	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Umbilical cord prolapse												
No ($n = 699$)	8.3	58	86.6	605	21.5	150	70.1	490	69.2*	484	14.4*	101
Yes ($n = 132$)	10.6	14	89.4	118	21.2	28	68.9	91	78.8*	104	7.6*	10
Preeclampsia												
No ($n = 812$)	8.3**	67	86.7	704	20.9*	170	70.1	569	70.8	575	12.9*	105
Yes ($n = 19$)	26.3**	5	100.0	19	42.1*	8	63.2	12	68.4	13	31.6*	6
Fetal distress												
No ($n = 777$)	8.6	67	86.1**	669	19.8**	154	69.5	540	71.8*	558	11.7**	91
Yes ($n = 54$)	9.3	5	100.0**	54	44.4**	24	75.9	41	55.6*	30	37.0**	20
Hypoxia												
No ($n = 815$)	8.6	70	87.0	709	21.0*	171	69.9	570	70.7	576	13.0*	106
Yes ($n = 16$)	12.5	2	87.5	14	43.8*	7	68.8	11	75.0	12	31.3*	5
Irregular Position												
No ($n = 773$)	8.9	69	87.6	677	21.5	166	70.5	545	72.8**	563	10.9**	84
Yes ($n = 58$)	5.2	3	79.3	46	20.7	12	62.1	36	43.1**	25	46.6**	27
Cephalo-pelvic disproportion												
No ($n = 776$)	8.6	67	86.3*	670	22.2*	172	70.2	545	74.4**	577	8.5**	66
Yes ($n = 55$)	9.1	5	96.4*	53	10.9*	6	65.5	36	20.0**	11	81.8**	45

Note: Total $N = 831$. This table is read across rows to identify percentage of cases, with and without delivery complications, that necessitated each specific medical intervention appearing in the columns. Inside bold lines are each of the three obstetrical complication scales identified by the PRINCALS SPSS procedure.

*$p < .05$; **$p < .01$.

socioeconomic job index for Canadians (Blishen, Carroll, & Moore, 1987), whereas family status indicated whether both biological parents were still living with the boy. For familial status, a score of 1 was given if the boy was not living with his two biological parents during his kindergarten year (30% of the sample). To be consistent with the familial status index, all other indices were given a score of 1 if they were below the 30th percentile in the present sample and a score of 0 if they were above the 30th percentile. The accumulation of these different variables has been shown to increase the risk of behavioral disorders by creating stressful rearing conditions (Kolvin, Miller, Fleeting, & Kolvin, 1988; Rutter, 1985). Because it was hypothesized that environmental conditions have an impact on behaviors early in life, only the age 6 measure of family adversity was used, because it represented the earliest index of the socioeconomic conditions in which the boy grew up. This composite measure of the degree of adversity in families at age 6 was shown to be predictive of stable childhood physical aggression in this sample and was highly correlated with age 12 family adversity scores, indicating its static nature (Haapasalo & Tremblay, 1994). In addition, this index was related to verbal learning difficulties (Séguin et al., 1995) and was associated with childhood externalizing disorders in a sample of over 3,000 French-speaking children (Vitaro, Tremblay, & Gagnon, 1992). The scores were standardized for easier interpretation of the results.

Self-reported delinquency. In the spring of the year they turned 17, the boys were asked to complete a questionnaire by rating items concerning their behavior at home, at school, and with their friends during the past 12 months. Among these items, 27 measured antisocial behavior. Theft was measured with 11 items: steal from school, steal from store, steal from home, keep object worth less than $10, steal bicycle, sell stolen goods, keep object worth between $10 and $100, steal object worth more than $100, breaking and entering, enter without paying, and trespassing. Six items were selected to evaluate vandalism: destroy school material, destroy other material, vandalize at school, destroy objects at home, vandalize a car, and set a fire. A substance use measure was made up of 3 items: take drugs, take alcohol, and get drunk. Seven items were used to measure violence: strong-arm, gang fights, use weapon in a fight, fistfight, beat up someone, carry a weapon, and throw objects at persons. Items were scored on a scale of 1 to 4 (never, once or twice, often, and very often) and summed to obtain a total frequency score on the four subscales. The Cronbach values for internal consistency of the theft, vandalism, substance use, and violence scales measured at age 17 were .87, .73, .82, and .78, respectively. Total scores on the first three scales were summed to represent self-reported nonviolent delinquency, whereas the last scale was considered self-reported violent delinquency. Theft, vandalism, substance use, and violence scales at ages 16 and 17 were significantly correlated, $r(765) = .67$, $r(762) = .45$, $r(764) = .72$, and $r(765) = .62$, respectively. Data at age 16 were used for 5.8% ($n = 58$) of the sample because of missing data at age 17. Nonviolent and violent delinquency subscales were significantly correlated, $r(846) = .63$, $p < .001$.

Because most 17-year-olds in the sample committed few antisocial acts, the distributions of the violent and the nonviolent delinquency scales were skewed. To distinguish those boys who committed delinquent acts only once or twice from the more serious offenders, the two measures of delinquency were dichotomized, using a 70th percentile cutoff point. This is the point at which the frequencies started to decrease, which may indicate a point at which antisocial acts, both violent and nonviolent, became less common. For each subscale, two groups were then created: a nondelinquent group that included nonoffenders and minimal offenders and a delinquent group that included more serious offenders.

Benefits of dichotomizing constructs related to delinquency are shown to outweigh the loss of information and statistical power in some cases (Farrington & Loeber, 2000; Loeber, Farrington, Stouthamer-Loeber, Moffitt, & Caspi, 1998): dichotomization does not engender a reduction in the strength of the expected association; permits the use of odds ratios (ORs), which make it easy to understand indicators of risk; identifies extreme cases, which is useful for explanation and prevention issues; and is not sensitive to the use of different cutoff points.

Physical aggression at age 6. Physical aggression scores at age 6 were generated from teachers' responses to three items on the Social Behavior Questionnaire (Tremblay et al., 1991): fights with other children; kicks, bites, hits other children; and bullies other children. Each item was scored on a frequency scale ranging from 0 to 2 (does not apply, sometimes, and frequently), and added to obtain a total score. The Cronbach value for internal consistency at age 6 was .88. Because the distribution of this variable was highly skewed, it was dichotomized at the 65th percentile to distinguish those boys who were rarely aggressive from the more seriously aggressive boys. Boys whose scores were lower than the 65th percentile (scores of 0 or 1) were labeled low physically aggressive boys ($n = 545$), whereas those whose scores were higher (between 2 and 6) were labeled high physically aggressive boys ($n = 304$).

Prevention Program

A prevention program aimed at reducing externalizing problems among participants was implemented over a 2-year period when the boys were age 8 to 9 years (Tremblay, Vitaro, et al., 1992b). The intervention mainly consisted of parent training, social skills training, and cognitive problem-solving skills training. Among a group of 319 boys classified as aggressive–hyperactive in kingergarten, 142 were randomly selected to participate in the program: A group of 46 aggressive–hyperactive boys participated in the prevention group, whereas 58 aggressive–hyperactive boys constitute an observation–control group. Because this treatment experience could have altered the development of antisocial behavior among boys when they were young (Vitaro & Tremblay, 1994), the intervention program was controlled for in the analyses on adolescent delinquency.

Statistical Analyses

First, to quantify and scale the obstetrical complication data set, a nonlinear principal component analysis as implemented in SPSS procedure PRINCALS (SPSS, 1998) was used, which determines quantitative values to nominally and ordinal scaled data, and reduces the dimensionality of the original data set by finding the principal components of the quantified variables (Van de Geer, 1993). This statistical technique assigns a numerical value, or category quantifications, to each category (occurrence versus nonoccurrence) in such a way as to maximize the total squared correlation of the quantified variables with the components (Gifi, 1990). The resulting quantifications depend on the frequency of the complications and on their interrelations. The numerical value assigned to a category of a complication is inversely related to its marginal frequency. This method seems to be an appropriate choice to overcome the methodological limitations associated with obstetrical complication data because it (1) quantifies each obstetrical complication according to its frequency, used in this study as an indicator of its severity; (2) assigns quantitative values to obstetrical complication data, taking into account their interrelations; and (3) determines clusters of obstetrical complication data that are statistically, and potentially theoretically, meaningful.

The creation of the obstetrical complication scales required four steps. The first step consisted of assigning quantitative values to the original data set by using the nonlinear principal component analysis. In the second step, each variable was recoded by using the quantifications from the nonlinear principal component analysis. In the third step, we proceeded with a rotation of the nonlinear principal components using a principal component analysis. Although it does not conserve the total variance, an oblique rotation was used because it was more successful at retrieving the main axes that were strongly nonorthogonal. In the fourth step, the obstetrical complication scales were constructed by adding up the new quantifications for each of the components observed in the principal component analysis.

Second, to verify the interactive effect between the obstetrical complication scales and family adversity on violent delinquency at age 17, logistic regressions were used. In the first step of the analysis, obstetrical complications, family adversity, and the intervention program were entered. At the second step, the interaction between obstetrical complications and family adversity was entered. When an interaction was found to be significant, scaling effects and nonlinear associations were controlled for (Hosmer & Lemeshow, 1989) by entering the quadratic effects of both obstetrical complications and family adversity in the third step of the model. These procedures were repeated separately for each obstetrical complication scale determined by the nonlinear principal component analysis. The same steps were followed when examining physical aggression at age 6, with the only difference being that the intervention program was excluded from the first step.

Third, to test the interactive effect between specific obstetrical complications and family adversity on the continuity of violence from ages 6 to 17, logistic regressions were used, with violent delinquency during adolescence as the dependent variable. Physical aggression at age 6 was entered in the first step, to assess the risk of aggressive boys becoming violent delinquents during adolescence. Obstetrical complications, family adversity, and their interaction were then entered in the second step, and the reduction in the adolescence violence risk associated with childhood physical aggression was examined after controlling for the interaction effect between obstetrical complications and family adversity. The difference in the ORs yielded an estimate of the percentage of the association between physical aggression at age 6 and violent delinquency at age 17 that is accounted for by the interaction between obstetrical complications and family adversity.

Fourth, to verify the specificity of the effects observed on violent delinquency as compared with nonviolent delinquency, logistic regressions were used, with nonviolent delinquency during adolescence as the dependent variable, controlling for violent delinquency. Obstetrical complications, family adversity,

the intervention program and violent delinquency were entered in the first step of the analysis; and the interaction between obstetrical complications and family adversity was entered in the second step. When an interaction was found to be significant, scaling effects and nonlinear associations were controlled for by entering quadratic effects of both obstetrical complications and family adversity in the third step of the model. These procedures were repeated separately for each obstetrical complication scale.

RESULTS

Quantifying Obstetrical Complication Data

Three principal components were determined by the nonlinear principal component analysis following the rule of thumb that each component eigenvalue must be greater than the total variance explained by one variable itself (1/12 in this study). The three unrotated components accounted for 40% of the total variance. These components were then rotated to move the interpretation of the results on the obstetrical complication data themselves. The quantifications obtained from the nonlinear principal component analysis are given for all complications for a better understanding of the scales and the relative importance of every complication within each scale. For each complication, an initial score of 0 represents the nonoccurence of a complication, and an initial score of 1 represents its occurrence. The new scores are the PRINCALS optimal quantifications. (A detailed description of the PRINCALS procedure and solution are available on request from the corresponding author.)

The first scale was labeled Atypical Presentation Situation (APS). It combined cephalo-pelvic disproportion, 0 = −.27, 1 = 3.76; irregular position of the baby, 0 = −.27, 1 = 3.65; hypoxia, 0 = −.14, 1 = 7.14; cesarean section, 0 = −.39, 1 = 2.55; and episiotomy, 0 = −1.56, 1 = .64. Episiotomy was in the opposite direction compared with the rest of the complications, indicating an inverse contribution to this scale. This scale represented a problematic delivery situation because the fetus presented itself in an abnormal way or because the head seemed too large for the mother's pelvis. High scores on this scale were obtained by a delivery situation in which respiratory distress, probably caused by an atypical presentation or a difficult passage of the head, necessitated a cesarean section rather than trying an episiotomy.

The second scale was labeled Distress Situation (DS) and comprised fetal distress, 0 = −.26, 1 = 3.79; hypoxia, 0 = −.14, 1 = 7.14; anesthesia, 0 = −2.59, 1 = .39; use of forceps, 0 = −.52, 1 = 1.92; medications, 0 = −1.52, 1 = .66; and episiotomy, 0 = −1.56, 1 = .64. This scale represented a situation in which the fetus showed signs of cardiac or respiratory distress. High scores on this scale indicated a delivery situation in which either fetal distress, hypoxia, or both occurred along with several medical interventions. Lower scores indicated the use of some minor medical interventions for reasons other than cardiac or respiratory distresses. Hypoxia was the indicator that had the highest weight in the last two scales, suggesting that it is a rare complication and a severe one as well, following our main assumption that rarity indicates severity.

The third scale, labeled Deadly Risk Situation (DRS), was defined by preeclampsia, 0 = −.15, 1 = 6.54; umbilical cord prolapse, 0 = −.43, 1 = 2.30; and induced labor, 0 = −.31, 1 = 3.25. This scale was composed of two severe complications that usually necessitate urgent medical interventions to save the fetus's life. The highest observed score in the sample represented a delivery in which induced labor was used probably to stop preeclampsia. Other high scores indicated situations in which preeclampsia occurred alone or with umbilical cord prolapse. Preeclampsia had the highest weight on this scale.

Because component loadings from the principal component analysis were of the same magnitude on the two first scales for hypoxia and episiotomy, they were included in both scales. To get a total score on each of the three scales, the PRINCALS scores on each scale were summed. The three obstetrical complication scales were standardized for comparative purposes in further analyses.

Predicting Age 17 Violent Delinquency

We then verified whether the interaction between obstetrical complication scales and childhood familial adversity could predict self-reported violent delinquency at age 17. Results for the logistic regression analysis with the APS scale indicated no significant interaction effect between obstetrical complications and family adversity on the risk of becoming violent delinquent, beyond the significant main effect of family adversity and the marginal effect of the intervention program (Table 3). Results for the DS scale indicated a significant interaction between obstetrical complications and family adversity beyond the significant main effect of family adversity and the marginal effect of the intervention program. The interaction became marginal, however, after including DS scale and family adversity quadratic effects in the model, β = .13, *SE* = .08, OR = 1.14, $p = .07$. This result suggests that the interaction effect between the

Table 3 Models Predicting Self-Reported Violent Delinquency at Age 17

Variables	β	*SE*	OR
Atypical Presentation Situation (APS)	−.08	.08	.92
Family adversity	.31	.07	1.36**
Intervention group	−.49	.42	.61
Observation group	.39	.27	1.48
APS × Family Adversity	−.04	.07	.96
Distress Situation (DS)	.02	.07	1.02
Family Adversity	.33	.08	1.40**
Intervention group	−.51	.42	.60
Observation group	.34	.28	1.41
DS × Family Adversity	.15	.07	1.16*
Deadly Risk Situation (DRS)	.01	.07	1.01
Family adversity	.32	.07	1.38**
Intervention group	−.47	.42	.63
Observation group	.37	.27	1.45
DRS × Family Adversity	.15	.08	1.17*

Note: $N = 849$. We used missing data indicators (Little & Rusin, 1987) to reduce listwise deletion of obstetrical complications data. To ensure that the findings were not influenced by categorizing the outcome variables, all three analyses were repeated using continuous measures of violent delinquency with ordinary least square regression (OLS). Results were consistent in both statistical strategies.
*$p < .05$; **$p < .01$.

DS scale and family adversity is partly attributable to a nonlinear effect of the DS scale and its correlation with family adversity, $r(847) = -.11$, $p < .001$.

Results indicated a significant interaction between the DRS scale and family adversity beyond the significant main effect of family adversity (Table 3). The interaction effect remained significant after testing the nonlinear effects of obstetrical complications and family adversity, $\beta = .16$, $SE = .09$, OR = 1.17, $p < .05$. This interaction indicates that obstetrical complications increased the likelihood of violent delinquency depending on the level of family adversity: for boys with high scores on the family adversity index, an increase of 1 *SD* on the DRS scale elevated the risk of violent delinquency at age 17 by a factor of 1.17.

Predicting Age 6 Physical Aggression

We verified whether the interaction between the DRS scale and family adversity on violent delinquency was already present during the kindergarten year. Results indicated that the interaction between the DRS scale and family adversity significantly predicted teacher-rated physical aggression in kindergarten, $\beta = .15$, $SE = .07$, OR = 1.16, $p < .05$, beyond the significant main effect of family adversity, $\beta = .36$, $SE = .06$, OR = 1.43, $p < .001$. The interaction remained significant, $\beta = .15$, $SE = .07$, OR = 1.16, $p < .05$, after testing the nonlinear effect of obstetrical complications and family adversity. Again, this interaction indicates that obstetrical complications increased the likelihood of physical aggression depending on the level of family adversity. For boys with high scores on the family adversity index, an increase of 1 *SD* on the DRS scale elevated the risk of physical aggression at age 6 by a factor of 1.16.

Explaining the Continuity of Violent Behavior from Childhood to Adolescence

The above findings suggest that the interaction of obstetrical complications (more specifically, preeclampsia, umbilical cord prolapse, and induced labor) with family adversity have an impact on both age 6 teacher-rated physical aggression and age 17 self-reported violent delinquency. It is still not clear, however, if that effect can account for the continuity of violence from childhood to adolescence.

As expected, physical aggression at age 6 was significantly associated with violent delinquency at age 17, $\beta = .49$, $SE = .16$, OR = 1.63, $p < .005$. Boys who were perceived as physically aggressive by their kindergarten teacher were 1.63 times more likely to report committing violent delinquent offenses at age 17. When the DRS scale, family adversity, and their interaction were entered in the second step of the analysis, a significant effect was observed for the interaction term, $\beta = .14$, $SE = .07$, OR = 1.15, $p = .05$, beyond significant main effects of family adversity, $\beta = .30$, $SE = .08$, OR = 1.35, $p < .001$, and physical aggression at age 6, $\beta = .34$, $SE = .16$, OR = 1.41, $p < .05$. Interestingly, the risk of violent delinquency for age 6 physically aggressive boys was reduced to 1.41, a change in the OR of 12.5%. This result indicates that specific obstetrical complications, family adversity, and their interaction explained 12.5% of the association between violent delinquency during adolescence with one of its most powerful predictors, childhood physical aggression.

Predicting Age 17 Nonviolent Delinquency

Finally, we tested whether the interaction between the DRS scale and family adversity predicted specifically violent delinquency as opposed to nonviolent delinquency. Results for the analysis with the APS and the DS scales indicated no significant interaction effect between obstetrical complications and family adversity on the risk of becoming nonviolent delinquent (Table 4). Results indicated a significant interaction effect between the DRS scale and family adversity, however, beyond the significant main effect of self-reported violent delinquency. The interaction ef-

Table 4 Models Predicting Self-Reported Nonviolent Delinquency at Age 17, Controlling for Violent Delinquency

Variables	β	*SE*	OR
Atypical Presentation Situation (APS)	−.02	.08	.98
Family adversity	−.07	.08	.93
Intervention group	−.66	.50	.52
Observation group	.51	.30	1.67
Self-reported violent delinquency	2.03	.18	6.61**
APS × Family Adversity	.03	.07	1.03
Distress Situation (DS)	−.02	.08	.98
Family adversity	−.07	.08	.93
Intervention group	−.66	.50	.51
Observation group	.51	.30	1.67
Self-reported violent delinquency	2.03	.18	7.59**
DS × Family Adversity	.02	.08	1.02
Deadly Risk Situation (DRS)	.09	.08	1.09
Family adversity	−.06	.08	.94
Intervention group	−.68	.50	.51
Observation group	.50	.30	1.65
Self-reported violent delinquency	2.02	.18	7.52**
DRS × Family Adversity	.21	.09	1.23*

Note: $N = 848$. To ensure that the findings were not influenced by categorizing the outcome variables, all three analyses were repeated using continuous measures of nonviolent delinquency with ordinary least square regression (OLS). Results were consistent in both statistical strategies.
* $p < .05$; ** $p < .01$.

fect remained significant after having tested the nonlinear effects of obstetrical complications and family adversity, β = .21, *SE* = .09, OR = 1.23, $p < .05$. This interaction indicates that obstetrical complications also increased the likelihood of nonviolent delinquency depending on the level of family adversity. For boys with high scores on the family adversity index, an increase of 1 *SD* on the DRS scale elevated the risk of nonviolent delinquency at age 17 by a factor of 1.23. Results from this analysis indicated that the significant interaction effect between the DRS scale and family adversity was not specific to violent delinquency, but rather delinquent behaviors in general.

DISCUSSION

This study, using self-reported and teacher-rated measures of behavior, showed that an interaction between obstetrical complications and psychosocial risk factors predicted adolescent violent and nonviolent delinquency. The results support previous studies that used conviction data (Piquero & Tibbetts, 1999; Raine et al., 1994, 1997), but go beyond that by showing that a specific composite of obstetrical complications was involved in the prediction, the impact of this interaction was observed as early as kindergarten, and it partly explained the continuity of violent behavior from ages 6 to 17. To our knowledge, this is the first study to demonstrate that a specific combination of obstetrical complications was involved in chronic physical violence from childhood onward.

Three obstetrical complication scales were created, based on a statistical technique that described different risky delivery situations. Rather than being an accumulation of various complications, these scales identified more specific delivery situations that could lead to a better identification of the physiological processes behind biological risk factors associated with violence. The results of this study indicate that it is the experience of specific obstetrical complications—namely, preeclampsia, umbilical cord prolapse, and induced labor—that influences the development of violent behavior. Like other studies on schizophrenia (Dalman et al., 1999; Kendell, Juszczak, & Cole, 1996; Zornberg, Buka, & Tsuang, 2000b), we found that within a set of complications, preeclampsia was a predominant contributor to the development of behavioral problems. Preeclampsia is part of the pregnancy-induced hypertension disorders category, and usually develops at the end of pregnancy (after the 20th week of gestation). Abnormal fetal blood flow, because of perfusion problems from the uterus to the placenta, may engender fetal growth retardation, preterm birth, and perinatal mortality. When the risk of mortality is elevated, induced labor is used to stop preeclampsia, but it increases the risk of umbilical cord prolapse (Ladewig, London, & Brookens Olds, 1990). According to the World Health Organization, preeclampsia is responsible for most maternal deaths and perinatal mortality (see Zeeman & Dekker, 1992).

In addition to creating a very high-risk delivery, preeclampsia may influence later behavior during the course of the pregnancy. A first hypothesis would be that because of preeclampsia, the fetus's normal nutrition supplies are compromised and may engender neuropsychological deficits, such as executive functions or verbal deficits. Executive function deficits have been shown to be an important risk factor for antisocial behavior (Moffitt & Henry, 1989; Séguin, Pihl, Boulerice, Tremblay, & Harden, 1996). A second hypothesis would be an intergenerational transmission of hypertension from a mother who had preeclampsia to her son. A history of familial hypertension is associated with a low level of pain sensitivity among adolescent boys (Ditto, Séguin, Boulerice, Pihl, & Tremblay, 1998) and a low level of pain sensitivity is linked to childhood stable physical aggression (Séguin et al., 1996). One could also expect that the fetus malnutrition could influence later behavior via low birth weight (Tibbetts & Piquero, 1999). The effect of the interaction between the DRS scale and family adversity,

however, remained significant after controlling for birth weight.

The observed interaction between obstetrical complications and family adversity indicates that the latter plays an important role in the development of early chronic physical aggression for boys who were subjected to preeclampsia, umbilical cord prolapse, or induced labor during delivery. Control over physical aggression appears to be learned by most children between the first and third year after birth (Tremblay et al., 1996; Tremblay et al., 1999). Systematic observations of the interactions between children and their environments, mostly with parents but also with siblings and peers, over the first 4 years of life could help to clarify why boys who have specific obstetrical complications and grow up in adverse family conditions fail to learn to control their physical aggression. These observational studies could also provide information about the support these families will need to help their sons learn alternatives to physical aggression. Such support could be, for example, to encourage longer maternal leave, especially for mothers who experienced obstetrical complications, to give them time to develop high-quality interactions with their newborns (Clark, Hyde, Essex, & Klein, 1997). The results of the present research also support studies showing that intensive support to pregnant young women from poor areas could have a significant impact on their behavior and the development of their children (Kitzman et al., 1997; Olds et al., 1997). These interventions can reduce the probabilities of complications during delivery and strengthen parenting abilities, which appears crucial once obstetrical complications occur.

Contrary to Raine et al. (1994) who showed that the interaction between birth complications was specific with early maternal rejection, the present study's results indicate that a broad measure of family adversity interacted with obstetrical complications to predict later violent behavior. The interaction effect found with family adversity may be specific to low SES populations. This would explain the similarity of the present findings with those of Piquero and Tibbetts (1999), who also examined a measure of disadvantaged familial environment. The different results may also be due to the differences in samples. This study used a sample of French-speaking boys from low-SES areas of Montréal, Canada, born between 1987 and 1988, whereas Raine et al. (1994, 1997) used the total birth population from a Copenhagen, Denmark, hospital between 1959 and 1961.

Contrary to previous studies (Piquero & Tibbetts, 1999; Raine et al., 1994, 1997), the results of the present study indicate that the interaction between specific obstetrical complications and family adversity predicted both violent and nonviolent delinquency in late adolescence. These differences are intriguing and may be caused by the fact that a self-reported delinquency measure was used, rather than official records. Conviction data capture only a small proportion of offenses committed (Elliott, 1994; Elliott et al., 1986), especially nonviolent offenses. The present findings may also be explained by the overlap of violent and nonviolent delinquency, as shown by the high correlation between the two measures in this study. This raises the question as to whether theories specifically related to violence are relevant to the study of antisocial behavior, or whether violence is primarily driven by offense frequency (Farrington, 1991; Piquero, 2000). Accordingly, violence would be one feature of a general spectrum of antisocial behavior and would share the same causes with nonviolent antisocial behavior. The difference in results could also be due to the groups that were compared. Raine et al. (1994) compared violent individuals with nonviolent criminals after having shown that the violent criminals were different from the noncriminals. The results indicated that the interaction distinguished the violent individuals from both the noncriminals and the nonviolent criminals. The nonviolent criminals were not compared with the noncriminals. These analyses then did not verify directly the specificity hypothesis. The interaction effect could explain differences in criminality, in general, as opposed to violence specifically, because this effect was not controlled for.

Finally, the present study's results should be interpreted with caution. First, the violence risk associated with the interaction between obstetrical complications and family adversity was small, but similar to the one found previously (Piquero & Tibbetts, 1999). Second, the sample was composed exclusively of males who came from deprived areas of a large city. Third, the obstetrical complication scales originated from an exploratory statistical exercise and require further validation. Fourth, it was not possible to estimate the impact of participants' attrition on the conclusions. In spite of these limitations, however, the conclusions suggest that future research should investigate the long-term physiological effects of obstetrical complications, more specifically preeclampsia and umbilical cord prolapse, to better understand the process from obstetrical complications to adolescent delinquent behavior for both males and females living in families with high levels of adversity.

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ADDRESSES AND AFFILIATIONS

Corresponding author: Richard E. Tremblay, Research Unit on Children's Psychosocial Maladjustment, 3050 blvd. Edouard-Montpetit, C.P. 6128 succursale Centre-ville, Montréal, Québec, Canada, H3C 3J7; e-mail: gripret@ere.umontreal.ca. Louise Arseneault was at the University of Montréal at the time of the study, and is now at the University of London, United Kingdom; Richard Tremblay and Bernard Boulerice are also at the University of Montréal; and Jean-François Saucier is at Ste-Justine Hospital, Montréal, Canada.

REFERENCES

Arseneault, L., Moffitt, T. E., Caspi, A., Taylor, P. J., & Silva, P. A. (2000). Mental disorders and violence in a total birth cohort: Results from the Dunedin Study. *Archives of General Psychiatry, 57*, 979-986.

Arseneault, L., Tremblay, R. E., Boulerice, B., Séguin, J. R., & Saucier, J.-F. (2000). Minor physical anomalies and family adversity as risk factors for violent delinquency in adolescence. *The American Journal of Psychiatry, 157*, 917–923.

Blishen, B. R., Carroll, W. K., & Moore, C. (1987). The 1981 socioeconomic index for occupations in Canada. *Canadian Review of Sociology and Anthropology, 24*, 465–488.

Brennan, P., Mednick, S. A., & Kandel, E. (1991). An early starter model for predicting delinquency. In D. J. Pepler & K. H. Rubin (Eds.), *The development and treatment of childhood aggression* (pp. 81–92). Hillsdale, NJ: Erlbaum.

Buka, S. L., Tsuang, M. T., & Lipsitt, L. P. (1993). Pregnancy / delivery complications and psychiatric diagnosis: A prospective study. *Archives of General Psychiatry, 50*, 151–156.

Cannon, M., & Jones, P. (1996). Schizophrenia. *Journal of Neurology, Neurosurgery, and Psychiatry, 61*, 604–613.

Cannon, T. D. (1997). On the nature and mechanisms of obstetric influences in schizophrenia: A review and synthesis of epidemiologic studies. *International Review of Psychiatry, 9*, 387–397.

Cannon, T. D., Mednick, S. A., & Parnas, J. (1989). Genetic and perinatal determinants of structural brain deficits in schizophrenia. *Archives of General Psychiatry, 46*, 883–889.

Cannon, T. D., Mednick, S. A., Parnas, J., Schulsinger, F., Praestholm, J., & Vestergaard, A. (1993). Developmental brain abnormalities in the offspring of schizophrenic mothers. *Archives of General Psychiatry, 50*, 551–564.

Cannon, T. D., Rosso, I. M., Hollister, J. M., Bearden, C. E., Sanchez, L. E., & Hadley, T. (2000). A prospective cohort study of genetic and perinatal influences in the etiology of schizophrenia. *Schizophrenia Bulletin, 26*, 351–366.

Caspi, A., Henry, B., McGee, R. O., Moffitt, T. E., & Silva, P. A. (1995). Temperamental origins of child and adolescent behavior problems: From age three to age fifteen. *Child Development, 66*, 55–68.

Caspi, A., & Silva, P. A. (1995). Temperamental qualities at age three predict personality traits in young adulthood: Longitudinal evidence from a birth cohort. *Child Development, 66*, 486–498.

Clark, R., Hyde, J., Essex, M. J., & Klein, M. K. (1997). Length of maternity leave and quality of mother-infant interactions. *Child Development, 68*, 364–383.

Dalman, C., Allebeck, P., Cullberg, J., Grunewald, C., & Köster, M. (1999). Obstetric complications and the risk of schizophrenia. *Archives of General Psychiatry, 56*, 234–240.

Ditto, B., Séguin, J. R., Boulerice, B., Pihl, R. O., & Tremblay, R. E. (1998). Risk for hypertension and pain sensitivity in adolescent boys. *Health Psychology, 17*, 249–254.

Elliott, D. S. (1994). Serious violent offenders: Onset, developmental course and termination. *Criminology, 32*, 1–21.

Elliott, D. S., Huizinga, D., & Morse, B. (1986). Self-reported violent offending: A descriptive analysis of juvenile violent offenders and their offending careers. *Journal of Interpersonal Violence, 4*, 472–514.

Farrington, D. P. (1991). Childhood aggression and adult violence: Early predictors and later life outcomes. In D. J. Pepler & K. H. Rubin (Eds.), The development and treatment of childhood aggression (pp. 5–29). Hillsdale, NJ: Erlbaum.

Farrington, D. P., & Loeber, R. (2000). Some benefits of dichotomization in psychiatric and criminological research. *Criminal Behaviour and Mental Health, 10*, 100–122.

Gifi, A. (1990). *Nonlinear multivariate analysis.* New York: Wiley.

Greenwood, P. W. (1995). Juvenile crime and juvenile justice. In J. Q. Wilson & J. Petersilia (Eds.), *Crime* (pp. 91–117). San Francisco: Institute for Contemporary Studies.

Haapasalo, J., & Tremblay, R. E. (1994). Physically aggressive boys from ages 6 to 12: Family background, parenting behavior, and prediction of delinquency. *Journal of Consulting and Clinical Psychology, 62*, 1044–1052.

Häfner, H., Maurer, K., Löffler, W., & Riecher-Rössler, A. (1993). The influence of age and sex on the onset and early course of schizophrenia. *British Journal of Psychiatry, 162*, 80–86.

Hodgins, S., Mednick, S. A., Brennan, P. A., Schulsinger, F., & Engberg, M. (1996). Mental disorder and crime: Evidence from a Danish birth cohort. *Archives of General Psychiatry, 53*, 489–496.

Hosmer, D. W., & Lemeshow, S. (1989). Applied logistic regression. New York: Wiley.

Junger-Tas, J., & Marshall, I. H. (1999). The self-report methodology in crime research. In M. Tonry (Ed.), *Crime and justice: A review of research* (pp. 291–367). Chicago: University of Chicago Press.

Kandel, E., & Mednick, S. A. (1991). Perinatal complications predict violent offending. *Criminology, 29*, 519–529.

Kendell, R. E., Juszczak, E., & Cole, S. K. (1996). Obstetric complications and schizophrenia: A case control study based on standardised obstetric records. *British Journal of Psychiatry, 168*, 556–561.

Kitzman, H., Olds, D. L., Henderson, C. R., Hanks, C., Cole, R., Tatelbaum, R., McConnochie, K. M., Sidora, K., Luckey, D. W., Shaver, D., Engelhardt, K., James, D., & Barnard, K. (1997). Effect of prenatal and infancy home visitation by nurses on pregnancy outcomes, childhood injuries, and repeated child-bearing: A randomized controlled trial. *Journal of the American Medical Association, 278*, 644–652.

Kolvin, I., Miller, F. J. W., Fleeting, M., & Kolvin, P. A. (1988). Social and parenting factors affecting criminal-offence rates: Findings from the Newcastle Thousand Family Study. *British Journal of Psychiatry, 152*, 80–90.

Ladewig, W., London, M. L., & Brookens Olds, S. (1990). *Essentials of maternal-newborn nursing.* Reading, MA: Addison-Wesley.

Loeber, R., Farrington, D. P., Stouthamer-Loeber, M., Moffitt, T. E., & Caspi, A. (1998). The development of male offending: Key findings from the first decade of the Pittsburgh Youth Study. *Studies on Crime and Crime Prevention, 7*, 141–171.

McNeil, T. F., Cantor-Graae, E., & Sjöström, K. (1994). Obstetric complications as antecedents of schizophrenia: Empirical effects of using different obstetric complication scales. *Journal of Psychiatric Research, 28*, 519–530.

Moffitt, T. E. (1990). Juvenile delinquency and attention deficit disorder: Boy's developmental trajectories from age 3 to age 15. *Child Development, 61*, 893–910.

Moffitt, T. E. (1993). Adolescence-limited and life-course persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100*, 674–701.

Moffitt, T. E., & Henry, B. (1989). Neuropsychological assessment of executive functions in self reported delinquents. *Development and Psychopathology, 1*, 105–118.

Nagin, D., & Tremblay, R. E. (1999). Trajectories of boys' physical aggression, opposition, and hyperactivity on the path to physically violent and nonviolent juvenile delinquency. *Child Development, 70*, 1181–1196.

O'Callaghan, E., Buckley, P., Madigan, C., Redmond, O., Stack, J. P., Kinsella, A., Larkin, C., Ennis, J. T., & Waddington, J. L. (1995). The relationship of minor physical anomalies and other putative indices of developmental disturbance in schizophrenia to abnormalities of cerebral structure on magnetic resonance imaging. *Biological Psychiatry, 38*, 516–524.

O'Dwyer, J. M. (1997). Schizophrenia in people with intellectual disability: The role of pregnancy and birth complications. *Journal of Intellectual Disability Research, 41*, 238–251.

Olds, D. L., Eckenrode, J., Henderson, C. R., Kitzman, H., Powers, J., Cole, R., Sidora, K., Morris, P., Pettitt, L. M., & Luckey, D. (1997). Long-term effects of home visitation on maternal life course and child abuse and neglect: Fifteen-year follow-up of a randomized trial. *Journal of the American Medical Association, 278*, 637–643.

Patterson, G. R. (1993). Orderly change in a stable world: The antisocial trait as a chimera. *Journal of Consulting and Clinical Psychology, 61*, 911–919.

Patterson, G. R., DeBaryshe, B. D., & Ramsey, E. (1989). A developmental perspective on antisocial behavior. *American Psychologist, 44*, 329–335.

Piquero, A. (2000). Frequency, specialization, and violence in offending careers. *Journal of Research in Crime and Delinquency, 37*, 392–418.

Piquero, A., & Tibbetts, S. (1999). The impact of pre/perinatal disturbances and disadvantaged familial environment in predicting criminal offending. *Studies on Crime and Crime Prevention, 8*, 52–70.

Raine, A., Brennan, P., & Mednick, S. A. (1994). Birth complications combined with early maternal rejection at age 1 year predispose to violent crime at age 18 years. *Archives of General Psychiatry, 51*, 984–988.

Raine, A., Brennan, P., & Mednick, S. A. (1997). Interaction between birth complications and early maternal rejection in predisposing individuals to adult violence: Specificity to serious, early-onset violence. *American Journal of Psychiatry, 154*, 1265–1271.

Rutter, M. (1985). Resilience in the face of adversity: Protective factors and resistance to psychiatric disorders. *British Journal of Psychiatry, 147*, 598–611.

Séguin, J. R., Pihl, R. O., Boulerice, B., Tremblay, R. E., & Harden, P. W. (1996). Pain sensitivity and stability of physical aggression in boys. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 37*, 823–834.

Séguin, J. R., Pihl, R. O., Harden, P. W., Tremblay, R. E., & Boulerice, B. (1995). Cognitive and neuropsychological characteristics of physically aggressive boys. *Journal of Abnormal Psychology, 104*, 614–624.

Seidman, L. J., Buka, S. L., Goldstein, J. M., Horton, N. J., Reider, R. O., & Tsuang, M. T. (2000). The relationship of prenatal and perinatal complications to cognitive functioning at age 7 in the New England cohorts of the National Collaborative Perinatal Project. *Schizophrenia Bulletin, 26*, 309–321.

SPSS. (1998). *SPSS categories 8.0.* Chicago, IL.

Stueve, A., & Link, B. G. (1997). Violence and psychiatric disorders: Results from an epidemiological study of young adults in Israel. *The Psychiatric Quarterly, 68*, 327–342.

Tibbetts, S. G., & Piquero, A. R. (1999). The influence of gender, low birth weight, and disadvantaged environment in predicting early onset of offending: A test of Moffitt's interactional hypothesis. *Criminology, 37*, 843–878.

Tiihonen, J., Isohanni, M., Räsänen, P., Koiranen, M., & Moring, J. (1997). Specific major mental disorders and criminality: A 26-year prospective study of the 1996 Northern Finland Birth Cohort. *American Journal of Psychiatry, 154*, 840–845.

Tremblay, R. E., Boulerice, B., Harden, P. W., McDuff, P., Pérusse, D., Pihl, R. O., & Zoccolillo, M. (1996). Do children in Canada become more aggressive as they approach adolescence? In Statistics Canada (Ed.), Growing up in Canada: National Longitudinal Survey of Children and Youth (pp. 127–137). Ottawa, Ontario: Human Resources Development Canada.

Tremblay, R. E., Japel, C., Pérusse, D., McDuff, P., Boivin, M., Zoccolillo, M., & Montplaisir, J. (1999). The search for the age of "onset" of physical aggression: Rousseau and Bandura revisited. *Criminal Behaviour and Mental Health, 9*, 8–23.

Tremblay, R. E., Loeber, R., Gagnon, C., Charlebois, P., Larivée, S., & LeBlanc, M. (1991). Disruptive boys with stable and unstable high fighting behavior patterns during junior elementary school. *Journal of Abnormal Child Psychology, 19*, 285–300.

Tremblay, R. E., Mâsse, B., Perron, D., LeBlanc, M., Schwartzman, A. E., & Ledingham, J. E. (1992). Early disruptive behavior, poor school achievement, delinquent behavior and delinquent personality: Longitudinal analyses. *Journal of Consulting and Clinical Psychology, 60*, 64–72.

Tremblay, R. E., Pihl, R. O., Vitaro, F., & Dobkin, P. L. (1994). Predicting early onset of male antisocial behavior from preschool behavior. *Archives of General Psychiatry, 51*, 732–738.

Tremblay, R. E., Vitaro, F., Bertrand, L., LeBlanc, M., Beauchesne, H., Boileau, H., & David, L. (1992). Parent and child training to prevent early onset of delinquency: The Montréal longitudinal-experimental study. In J. McCord & R. E. Tremblay (Eds.), *Preventing deviant behavior from birth to adolescence: Experimental approaches* (pp. 117–138). New York: Guilford.

Van de Geer, J. P. (1993). *Multivariate analysis of categorical data: Theory.* Newbury Park, CA: Sage.

Vitaro, F., & Tremblay, R. E. (1994). Impact of a prevention program on aggressive children's friendships and social adjustment. *Journal of Abnormal Child Psychology, 22*, 457–475.

Vitaro, F., Tremblay, R. E., & Gagnon, C. (1992). Family adversity and behavior problems in early school years. *Revue Canadienne de Santé Mentale, 11*, 45–62.

White, J. L., Moffitt, T. E., Earls, F., Robins, L., & Silva, P. A. (1990). How early can we tell? Predictors of childhood conduct disorder and adolescent delinquency. *Criminology, 28*, 507–533.

Zeeman, G. G., & Dekker, G. A. (1992). Pathogenesis of preeclampsia: A hypothesis. *Clinical Obstetrics and Gynecology, 35*, 317–337.

Zornberg, G. L., Buka, S. L., & Tsuang, M. T. (2000a). At issue: The problem of obstetrical complications and schizophenia. *Schizophrenia Bulletin, 26*, 249–256.

Zornberg, G. L., Buka, S. L., & Tsuang, M. T. (2000b). Hypoxic-ischema-related fetal/neonatal complications and risk of schizophrenia and other nonaffective psychoses: A 19-year longitudinal study. *American Journal of Psychiatry, 157*, 196–202.