High rates of violence, crime, academic problems, and behavioral problems in males with both early neuromotor deficits and unstable family environments

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High Rates of Violence, Crime, Academic Problems, and Behavioral Problems in Males With Both Early Neuromotor Deficits and Unstable Family Environments

Adrian Raine, PhD; Patricia Brennan, PhD; Birgitte Mednick, PhD; Sarnoff A. Mednick, PhD, DM

Background: It is commonly assumed that individuals with both biological and psychosocial deficits are more likely to become criminal, but there is surprisingly little empirical support for this assumption. We test the hypothesis that a group with biosocial risk factors are more likely to develop behavioral and academic problems in adolescence and violent criminal offending in adulthood compared with groups with only biological or only social risk factors.

Methods: Hypotheses were tested on a sample of 397 male subjects, using obstetric and early neuromotor measures collected in the first year of life; family, social, demographic, and behavioral measures at age 17 to 19 years; and criminal data at 20 to 22 years of age.

Results: Cluster analysis of the risk factors indicated a group with obstetric risk factors only, a group with poverty risk factors only, and a biosocial group with both early neuromotor deficits and unstable family environments. The biosocial group had more than double the adult violence, theft, and total crime rates of the other 2 groups and had significantly more behavioral and academic problems in adolescence.

Conclusions: When early neuromotor deficits and negative family factors cluster together, individuals are particularly likely to become criminal and violent compared with those with only poverty or only obstetric risk factors. Because this biosocial group accounted for 70.2% of all crimes committed in the entire sample, early interventions that tackle these deficits might significantly reduce violence.

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A long-standing view held by many criminologists is that while biological processes may play a minor role in predisposing to crime in a small, disturbed subgroup of offenders, social factors are the primary determinants of crime.1,4 This traditional perspective is currently being challenged by a biosocial approach to crime,5-13 an approach that has its roots in the earlier criminological literature.11-13 In addition to arguing that one subgroup commits crimes largely because of social factors, while another subgroup commits crime largely because of biological factors, this biosocial approach theorizes that a substantial third subgroup of subjects can be identified who commit crime largely because of both social and biological predispositions to crime.16 There are surprisingly few convincing empirical examples of the biosocial approach, primarily because strong studies require both social and biological measures to be prospectively collected on large samples. One recent study on 4269 live male births16 provides strong support for a biosocial approach, showing that maternal rejection of the child in the first year was found to statistically interact (P<.001) with birth complications in predicting to criminal violence at age 18 years. Subjects with both birth complications and maternal rejection made up only 4.4% of the sample but accounted for 18% of all violent crimes committed by the entire sample of 4269. There are some limitations to this study: (1) it dealt only with 1 biological and 1 social risk factor for violence; (2) official crime data were only available during adolescence; and (3) no other measures were available to validate the official crime data, such as ratings by parents of early behavior problems.

The present study attempts to address some of the above-mentioned limitations. Approximately 10% of the original sample of 4269 males used by Raine et al16 were randomly selected for further follow-up at ages...
SUBJECTS AND METHODS

SUBJECTS

Subjects were drawn from a larger initial cohort of 4269 males born in the maternity department of the State University Hospital (Rigshospitalet) in Copenhagen, Denmark, between September 1959 and December 1961.16,17 Ten percent (n = 423) of this larger sample were randomly selected to participate in a long-term follow-up at ages 17 to 19 years, which took place between 1977 and 1979. In total, 397 males (93%) made up the follow-up sample employed in the current study, with 7% of subjects being unavailable because of refusal to participate, death, and emigration.17 Informed consent for human investigation was obtained from the parents. Only data for male subjects were analyzed because the low rates of crime and violence in female subjects precluded meaningful statistical analyses.

Analyses indicated that the subjects who were included in the 17- to 19-year follow-up were virtually identical with the larger population in terms of mother's age at birth, birth order, family size, and marital stability (see Baker and Mednick17). Comparisons with the general Danish population indicated that although the follow-up sample was representative of the entire range of the national socioeconomic status (SES) distribution, mean SES was slightly lower because the original cohort included a disproportionate number of unwed, low-SES mothers from poorer inner-city areas of Copenhagen. The Rigshospitalet had also had referred mothers who were expected to experience difficult deliveries irrespective of mothers' social background.17 Consequently, the follow-up sample was similar to the national population with the exception that it comprised (1) women of lower SES and (2) women with difficult pregnancies who were expected to have birth complications.

METHODS

Biological Measures

Data on all biological measures were collected prospectively. They were available for all 397 subjects and have previously been shown to be relevant to crime and delinquency.22,23 Each weighted frequency scale was based on multiple items coded on a 1- to 5-point scale developed through the collaboration of American and Danish obstetricians and pediatric neurologists.12,22 In all cases, higher scores on these scales indicate poorer biological status. Full details of these scales are provided by Baker and Mednick,17 while brief details are given below.

Pregnancy complications were recorded and rated as early as possible in pregnancy during mothers' attendance at the hospital's antenatal clinic. The same physician conducted all prenatal examinations to help ensure uniform coding of obstetric histories. Examples of items include bacterial infection (scored 1), placenta previa (scored 5).

Birth complications and conditions were recorded at the time of delivery by an obstetrician assisted by a midwife.16 Examples include ruptured perineum (scored 1), umbilical cord prolapse (scored 5).

Nonmatuity scale consisted of items concerning the neonate's physical maturity at birth (gestation, birth weight). Examples include birth stage 34 to 35 weeks and weight 2500 to 3000 g (scored 1); birth stage less than 28 weeks and weight less than 1000 g (scored 5).

Neurological status (days 1 and 3) was established by a full neonatal neurological examination conducted at days 1 and 5 by a pediatrician. Examples include shivering, restlessness, and frog position (scored 1); repeated cyanosis attacks (scored 5).

Motor development (1 year) was examined by a team of 3 pediatricians on the child's first birthday at the pediatric outpatient department of the State University Hospital. The protocol for the examinations was developed by a joint team of Danish and American pediatricians representing both clinical and research expertise. Examples include does not stand with support or crawl until 11 to 12 months (scored 1), does not hold head up until after 9 months (scored 5).

Psychosocial, Family, and Demographic Measures

Psychosocial variables were selected and constructed from this data set on the basis of their relevance to criminal behavior.22,23 The psychosocial and family data were retrospectively obtained from a 2-hour interview with the mother at the 17- to 19-year follow-up. Interviews were conducted by a trained psychiatric social worker at the mother's home, while family size and birth order data were confirmed with reference to the Danish National Population Register. Data on early maternal rejection were collected from a psychosocial interview conducted with the mother when the child was 1 year old.

Early maternal rejection is described in full by Raine et al. Briefly, its measure was based on factor scores derived from a factor of "Early Child Rejection" based on items with the following loadings: public institutional care of infant (0.68), attempt to abort fetus (0.65), and unwanted pregnancy (0.44). Public care was defined as placement of the infant for care into a full-time public institution for more than 4 months of the first year. High scores indicate relatively greater rejection.

Social, economic, educational, employment, and living status was measured on the basis of the following 7 items drawn from the psychosocial interview with the mother: mother's occupation, father's occupation, periods of unemployment, periods of economic hardship, mother's years of education, number of rooms per person, and conditions of home furnishings. Full details of the derivation of these variables were reported by Baker and Mednick. Scores on each of the items were transformed to z scores and summed to form an overall scale, which, for ease of reference, was labeled "social deprivation," with high scores indicating greater deprivation; coefficient α for this scale was .77.

Marital conflict was measured using 9 items derived from the psychosocial interview of the mother and consisted of disagreements between parents concerning child raising, sharing of household chores, money, problems with

Continued on next page

17 to 19 years on a wider array of social, family, and biological variables than were available on the original sample. Additional variables included income and unemployment, marital conflict, family instability, and parental crime.17 In addition, official crime data on the subjects were available for a longer follow-up period than in the original study, while new data on maternal ratings of behavioral and academic problems at ages 17 to 19 years were also available.
in-laws, spare time activities, sexual problems, jealousy, other problems, and 1 partner always giving in during an argument. Mothers rated each item on a 1- to 4-point scale (1, no disagreements, and 4, major disagreements) for the longest spousal relationship they had been in since the subject was born. The item concerning 1 partner always giving in during an argument was rated on a 1- to 4-point scale (1, very untrue, and 4, very true). High scores indicate high levels of marital conflict; coefficient α for this scale was .84.

Family instability measured by the extent of disruption to the family was indexed by 3 items taken from the mother's psychosocial interview as follows: (1) number of marriages of mother in child's first 18 years, (2) number of changes in the family constellation of the household (defined as a movement in or out of the house by an adult member) up to age 18 years, and (3) number of years father lived in the household (fewer years indicated greater instability). High scores indicated relatively greater family instability; coefficient α for this scale was .66.

Parental crime was coded on the basis of how many parents (0, 1, or 2) had been arrested for an offense, as indicated by registration in the Danish National Criminal Register (see below).

Behavioral Outcome Measures

Criminal Offending. Criminal status for all 397 subjects was assessed in 1981, when offspring were aged 20 to 22 years, by a search of the Danish National Criminal Register in which all police contacts and court decisions involving Danish citizens are recorded. This is viewed as one of the most comprehensive and accurate registers in the Western world.17,35

Three indexes of criminal offending were constructed: (1) violence, (2) thievery, and (3) total offending. The definition of violence used by the National Academy of Sciences Panel on the Understanding and Control of Violence ("behaviors by individuals that intentionally threaten, attempt, or inflict physical harm on others") was used. Consequently, violent crime was defined by arrests for the following offenses: murder, attempted murder, assault (including domestic assault), rape, robbery and armed robbery, illegal possession of a weapon, and threats of violence. In contrast, thievery was defined as all types of property offending, including theft, breaking and entering, shoplifting, fraud, forgery, blackmail, and embezzlement. In addition, a third index, total criminal offending was compiled, in which all index offenses were included. Index offenses consisted of violence, thievery, sexual offenses (including prostitution and pimping), drug offenses, and narcotics offenses. In total, 23.9% of the sample were registered for a criminal index offense, 19.4% had a registration for thievery, and 8.6% had a registration for violence.

Ratings of Behavioral and Academic Problems. These measures consisted of maternal ratings of the subject's behavioral and academic functioning at ages 17 to 19 years, using a 1- to 3-point scale (1, never; 2, sometimes; and 3, often). Ratings were available on 394 of the 397 subjects. Specifically, 4 scales were constructed to estimate these behaviors as follows:

1. The Externalizing behavioral problems scale consisted of the following 5 items: aggressive, irritable, disobedient, lying, and restless/hyperactive. Higher scores indicated greater externalizing problems; coefficient α for this scale was .65.

2. The Internalizing behavioral problems scale consisted of the following 4 items: lonely, nervous, very passive, and often teased. Higher scores indicated greater internalizing problems; coefficient α for this scale was 0.60.

3. The Total behavior problems scale consisted of the 9 items making up the above 2 scales summed to create this overall measure of behavior problems that had an internal reliability of 0.71.

4. The Academic problems scale consisted of the following 6 items: repeated a grade, needed tutoring, attended special classes, poor math class achievement, poor language class achievement, and poor Danish class achievement. Items were coded so that high scores on the scale indicated relatively more academic problems; coefficient α for this scale was 0.74.

Statistical Analyses

Cluster Analysis of Risk Variables. To assess whether coherent subgroups of subjects could be identified based on the risk factors, 5 biological and 5 psychosocial risk variables were subjected to cluster analysis using SPSS (Statistical Package for the Social Sciences [SPSS Inc, Chicago, III]). Cluster analysis has numerous advocates in the field of psychopathology and psychology.18,19,20 and there have been over 1000 cluster analytic studies published in the past 10 years in psychiatry, psychology, and medicine. Cluster analysis is a classification technique that statistically seeks out naturally occurring homogeneous subgroups within a population on the basis of the characteristics used to identify the groups (in this case, social and biological risk factors for crime). Consequently, 1 main advantage of this technique over other multivariate techniques lies in its ability to define groups using statistical algorithms as opposed to predetermined cutoffs imposed by the experimenter.

Variables were first transformed to z scores to standardize measures before entry into an agglomerative hierarchical cluster analysis. Ward’s method was used to optimize minimum variance between clusters in conjunction with a squared Euclidean distance measure to assess similarity between subjects. Inspection of fusion coefficients and the dendrogram were used to help identify the number of clusters.18,21

The 3-cluster solution produced groups that were approximately equal in size and were defined by social variables only, biological variables only, and both biological and social variables. To help clarify the identity of the 3 clusters, analyses of variances were conducted on the biological and social risk variables.

Treatment of Missing Data. Sample sizes for the analyses on behavioral and academic problems varied slightly as a function of missing data (n=393, n=396, and n=373). Consequently, all analyses were recalculated on the reduced sample of 373. Results were identical to analyses reported above, with exactly the same configuration of main effects and between-groups differences.
Table 1. Mean (SD) and Least Significant Difference Comparisons of Biological and Social $z$-Transformed Variables for the Biosocial, Obstetric, and Poverty Clusters

<table>
<thead>
<tr>
<th>Measures</th>
<th>Cluster 1 (n=176)</th>
<th>Cluster 2 (n=106)</th>
<th>Cluster 3 (n=115)</th>
<th>F</th>
<th>Least Significant Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pregnancy</td>
<td>-0.34 (0.70)</td>
<td>0.85 (1.11)</td>
<td>-0.33 (0.76)</td>
<td>76†</td>
<td>2&gt;.1,3</td>
</tr>
<tr>
<td>Delivery</td>
<td>-0.32 (0.83)</td>
<td>0.84 (1.13)</td>
<td>-0.28 (0.62)</td>
<td>67†</td>
<td>2&gt;.1,3</td>
</tr>
<tr>
<td>Prematurity</td>
<td>-0.17 (0.68)</td>
<td>0.65 (1.40)</td>
<td>-0.35 (0.64)</td>
<td>38†</td>
<td>2&gt;.1,3</td>
</tr>
<tr>
<td>Motor</td>
<td>0.18 (0.95)</td>
<td>0.25 (1.2)</td>
<td>-0.53 (0.66)</td>
<td>25†</td>
<td>1.2&gt;.3</td>
</tr>
<tr>
<td>Neurological</td>
<td>0.20 (1.29)</td>
<td>-0.06 (0.69)</td>
<td>-0.26 (0.67)</td>
<td>7.7†</td>
<td>1&gt;.2,3</td>
</tr>
<tr>
<td>Social</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poverty</td>
<td>-0.50 (0.73)</td>
<td>0.15 (0.92)</td>
<td>0.68 (0.97)</td>
<td>68†</td>
<td>3&gt;.2,1</td>
</tr>
<tr>
<td>Family instability</td>
<td>0.46 (1.10)</td>
<td>-0.28 (0.75)</td>
<td>-0.51 (0.58)</td>
<td>50†</td>
<td>1&gt;.2,3</td>
</tr>
<tr>
<td>Marital conflict</td>
<td>0.39 (1.01)</td>
<td>-0.10 (0.91)</td>
<td>-0.49 (0.80)</td>
<td>32†</td>
<td>1&gt;.2,3</td>
</tr>
<tr>
<td>Rejection</td>
<td>0.39 (1.25)</td>
<td>-0.30 (0.64)</td>
<td>-0.32 (0.50)</td>
<td>27†</td>
<td>1&gt;.2,3</td>
</tr>
<tr>
<td>Parent crime</td>
<td>0.29 (1.4)</td>
<td>-0.14 (0.49)</td>
<td>-0.30 (0.23)</td>
<td>13†</td>
<td>1&gt;.2,3</td>
</tr>
</tbody>
</table>

*All P<.05.
†P<.001.
‡P<.005.

Table 2. Summary Characteristics of the Biosocial, Obstetric, and Poverty Clusters

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Cluster 1 (n=176)</th>
<th>Cluster 2 (n=106)</th>
<th>Cluster 3 (n=115)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td></td>
<td></td>
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<tr>
<td>Poverty</td>
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<td></td>
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<tr>
<td>Marital conflict</td>
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<tr>
<td>Maternal rejection</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family instability</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental crime</td>
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<tr>
<td>Biological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurological problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow motor development</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth complications</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Nonmaturity</td>
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</tr>
</tbody>
</table>

*Plus sign indicates risk factor present; minus sign, relatively lower marital conflict and faster motor development.

Delineated that possessed both social and biological risk factors for crime, this biosocial subgroup would commit more crime and have more behavioral and academic problems than subgroups that possessed social predispositions only or biological predispositions only.

**RESULTS**

Results of the cluster analysis are shown in Table 1, and the defining characteristics of each cluster are shown in Table 2.

Cluster 1 (n=176) was characterized by neurological problems in the first week of life (P<.005), slow motor development at age 1 year (P<.001), early maternal rejection (P<.001), family conflict (P<.001), family instability (P<.001), and criminal parent (P<.001). Because this cluster had both biological and social risk factors for crime development, this subgroup is labeled “biosocial.”

Cluster 2 (n=106), in contrast, was defined solely in terms of biological deficits, including relatively greater pregnancy complications (P<.001), birth complications (P<.001), prematurity (P<.001), and slower motor development (P<.001). For referencing purposes, this subgroup was labeled “obstetric.”

Cluster 3 (n=115) was characterized by having relatively more negative social, economic, educational, employment, and living status characteristics compared with those in the other 2 groups (P<.001). It was thus labeled “poverty,” although it should be noted that subjects also possess 2 positive features by virtue of having relatively lower marital discord (P<.001) and faster motor development (P<.001). This group is characterized by the social deficit of poverty, in contrast to the social characteristics of the biosocial group that specifically pertain to the domain of unstable, conflictual, or criminal family environment.

**SUBGROUP DIFFERENCES ON CRIMINAL OUTCOME MEASURES**

Rates of criminality in the 3 subgroups were compared using $\chi^2$ analyses. Results of these analyses for total criminal offending, thievery, and violence are illustrated in the *Figure*.

For total criminal offending, groups differed in rates of crime ($\chi^2=14.3, df=2, P<.001$). A breakdown of this overall group difference using $2\times2$ $\chi^2$ analyses indicated that the biosocial group had significantly higher rates of crime (33%) than both the obstetric (17.9%) ($\chi^2=7.5, df=1, P<.006$) and poverty (15.7%) ($\chi^2=10.8, df=1, P<.001$) groups that did not differ from each other (P>.65). Parental crime per se does not account for the high crime rates in the biosocial group, which still had higher crime rates than the other 2 groups after removing the influence of parental crime.

For thievery, groups differed in rates of crime ($\chi^2=18.6, df=2, P<.001$). A breakdown of this overall effect indicated that the biosocial group had significantly higher thievery...
rates (29%) than both the obstetric group (12.5%) ($\chi^2=10.5$, $df=1$, $P<.002$) and the poverty group (11.3%) ($\chi^2=12.7$, $df=1$, $P<.001$) that did not differ from each other ($P>.82$).

For violent offending, the overall analysis was significant ($\chi^2=7.4$, $df=2$, $P<.03$). A breakdown of the overall effect indicated that the biosocial group had significantly higher violence rates (12.5%) than the poverty group (3.5%) ($\chi^2=7.0$, $df=1$, $P<.009$). Although the biosocial group had higher violence rates than the obstetric group (7.5%), this difference was not statistically significant ($\chi^2=1.7$, $df=1$, $P>.19$). Obstetric and poverty groups did not differ significantly on violence ($P>.82$).

SUBGROUP DIFFERENCES ON BEHAVIORAL AND ACADEMIC PROBLEMS

Table 3 provides means and SDs for behavioral and academic problems in the biosocial, obstetric, and poverty clusters. Full details of 1-way analysis of variance and individual group comparisons for these variables are also given in Table 3. Briefly, the biosocial cluster had significantly more academic, externalizing, and internalizing behavior problems than did the poverty cluster ($P<.05$) and significantly more behavior problems than the obstetric group ($P<.05$).

COMPARISONS WITH SUBJECTS WITH NEITHER BIOLOGICAL NOR SOCIAL DEFICITS

The cluster analysis did not produce a group low on all risk factors. To compare the biosocial cluster with such a group of “normal controls,” subjects who were scored below the mean on all variables that defined the biosocial group (see Table 2) were drawn from obstetric and poverty clusters to form this normal control group (n=44). Results of these analyses confirmed that the biosocial group had significantly higher rates of total criminal offending than normal controls (33.1% vs 2.3%; $\chi^2=17.0$, $df=1$, $P<.001$), of thievery (29.1% vs 0.0%; $\chi^2=16.7$, $df=1$, $P<.001$), and of violence (12.6% vs 2.3%; $\chi^2=4.0$, $df=1$, $P<.05$).

The key finding from this article is that rates of crime are particularly high in a subgroup of subjects who possess both biological (early neuromotor deficits) and psychosocial (unstable family environments) risk factors for crime. This biosocial group had 2.0 times the level of total crime of the other 2 groups, 2.5 times the level of thievery, and 2.3 times the level of violence. The fact that the biosocial group also showed significantly more mother-reported behavioral and academic problems than the other 2 groups provides additional support for the findings based on official crime records. An important next step in this line of research would be to generalize findings from a Danish population to a more heterogeneous US population.

Results confirm the presence of a subgroup with both biological and social predispositions to crime and provide some support for the conceptual importance of a biosocial approach to crime. Although the importance of this biosocial approach has been frequently acknowledged, there have been surprisingly few convincing empirical demonstrations of its validity. Although purely biological and purely social research on crime may continue to be productive, this study suggests that one of the major future advances in understanding crime causation will be derived from a biosocial approach. As such, social researchers cannot continue to ignore the research findings of biological researchers and vice versa.

One interesting result of the study is that the poverty group, which was characterized by multiple social, economic, educational, employment, and living status problems, had the lowest rates of crime relative to the other 2 groups. This finding challenges the traditional stereotype of poverty and crime going hand in hand and instead suggests that such associated stigmatization of all

![Percentages of poverty, obstetric, and biosocial cluster members who become thieves and violent criminal offenders by ages 20 to 22 years.](image-url)
poor, underserved populations, although not intention, is unjustified. Crime was probably not elevated in this impoverished but resilient group compared with the other 2 groups because parents had a relatively more satisfactory and harmonious marital life and the children had relatively faster (not slower) motor development in infancy. As such, this socially impoverished group possessed 1 biological and 1 social protective factor against crime development. This is a potentially important finding in that good parenting and good early health development may compensate for the otherwise ill effects of low income and unemployment.

Findings have potentially important implications for treatment and intervention programs. The fact that biological and psychosocial factors converged in the group with high crime rates (biosocial cluster) indicates that tackling one or the other or both of these components could reduce crime and violence. At the biological level, better postnatal care could help early neurological and motor deficits to be identified and remediated before they translate into child behavior problems, cognitive deficits, school failure, and ultimately criminal behavior.49,50 Alternatively, tackling the psychosocial half of the biosocial equation could be equally effective. School interventions aimed at educating young adolescents on parent-child management, conflict resolution in the family, and family planning may help reduce rates of later marital conflict, family instability, and child rejection, which are critical components of the biosocial cluster.51,52 Because the biosocial group accounted for 70.2% of all crimes committed in the sample, successful intervention could, in theory, have a major effect in reducing rates of crime and violence. Because several of the variables making up the biosocial cluster (eg, neurological and motor development, maternal rejection) reflect very early (year 1) life processes, interventions may be most effectively employed in early childhood rather than in adolescence or early adulthood. Experimental intervention studies are first needed, however, to establish the causal significance of biosocial risk factors.

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