# Study review of the biological, social and environmental factors associated with aggressive behavior

# Estudo de revisão dos fatores biológicos, sociais e ambientais associados com o comportamento agressivo

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*Abstract*

***Objectives:*** *To study the risk factors leading to the development of aggressive behavior.* ***Method:*** *A search was conducted for retrospective, longitudinal and review studies on risk factors for the development of aggressive behavior in two electronic databases, Medline and SciELO.* ***Results:*** *Eleven longitudinal studies were selected of which 8 were prospective and 3 were case-control studies, and a cross sectional study evaluating the biological and socio-environmental risk factors related to aggressive behavior. Five studies studied gene expression, five the exposure to tobacco, alcohol and cocaine in the prenatal period, one the effect of early malnutrition on the development of aggressive behavior and another one the impact of child maltreatment.* ***Conclusion:*** *The main biological factors were genetic (low expression of the monoamine oxidase gene and the serotonin transporter gene, variations in transporter and dopamine receptor genes), exposure to substances during intrauterine development (tobacco, alcohol and cocaine) and nutrition (malnutrition). The main environmental factors were child abuse, poverty, crime and antisocial behavior at childhood, while the most evidence-based factor was early neglect. The interaction between biological and environmental factors can be catalyzed by a hostile environment, thus increasing the risk for the development of aggressive behavior.*

***Descriptors:*** *Violence; Risk factors; Review; Aggression; Antisocial personality disorder*

*Resumo*

***Objetivos:*** *Estudar os fatores de risco relacionados ao desenvolvimento do comportamento agressivo.* ***Método:*** *Foi realizada uma busca em duas bases de dados eletrônicas, Medline e SciELO, por estudos retrospectivos, longitudinais e de revisão que avaliaram fatores de risco para o desenvolvimento do comportamento agressivo.* ***Resultados:*** *Foram selecionados 11 estudos longitudinais (8 prospectivos e 3 de casos-controle) e um transversal que avaliaram os fatores de risco biológicos e socioambientais relacionados ao comportamento agressivo. Cinco estudos avaliaram a expressão gênica, cinco a exposição ao tabaco, ao álcool e a cocaína no período pré-natal, um avaliou as implicações da desnutrição precoce no desenvolvimento do comportamento agressivo e um avaliou o impacto dos maus tratos na infância.* ***Conclusão:*** *Os principais fatores biológicos encontrados foram: genéticos (baixa expressão do gene monoaminaoxidase e do gene transportador de serotonina, variações nos genes transportador e receptor de dopamina), exposição a substâncias durante o desenvolvimento intrauterino (tabaco, álcool e cocaína) e nutricionais (desnutrição infantil). Os principais fatores socioambientais encontrados foram: maus tratos na infância, pobreza, criminalidade e comportamento antissocial na infância, sendo que o maior nível de evidência esteve relacionado à negligência precoce. A interação entre fatores biológicos e ambientais pode ser catalisada por um ambiente hostil aumentando os riscos para o desenvolvimento de comportamentos agressivos.*

***Descritores:*** *Violência; Fatores de risco; Revisão; Agressão; Transtorno de personalidade anti-social*

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## Introduction

In its Resolution 49.25, adopted in 1961,[1] the World Health Organization (WHO) declared violence a major public health problem. Violence rates, whose main victims are the youth, women and children, have been increasing. The WHO defines violence as *"the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation".*[2] Aggressiveness, in turn, can be defined as the generation of a behavior that aims at causing physical or psychic harm to somebody else.[3-5]

In Brazil, external causes are the most usual cause of death, second only to cardiovascular diseases. The first external cause of death is homicide, followed by fatal traffic accidents. Young males are the most common fatal victims of violence in Brazil.[6,7] Studies on the burden of a disease, which measures the number of years of life lost to premature death or disability, indicate that external causes represent 10.2% of a disease's total burden.[8] Unfortunately, aside from homicides, other forms of violence are part of the day-to-day of our society: violence against one's partner, sexual abuse at childhood and adolescence, early involvement with alcohol and drugs, kidnappings, and violence against the elderly.[9]

In light of the current scenario, the study of risk factors for the development of an aggressive behavior, as well as prevention factors against it are of the utmost importance. The first research studies ever conducted in this field focused on social and environmental issues leading to aggressiveness. They pointed to social inequality, poverty and the environment as the main reasons for the display of an aggressive and criminal behavior.[10,11] However, as current research in neurosciences uncovered the biological, i.e. the genetic and neurophysiological mechanisms implicated in aggressive behavior, it became evident that both social and environmental factors are not the only reasons explaining the development of aggressive and anti-social behavior. As a matter of fact, what happens is an interaction between the biological and socio-environmental factors that modulate violent behavior. The aim of this study, therefore, is to conduct a comprehensive review of the current literature on the main risk factors associated with aggressive behavior.

## Method

The search for articles consisted in seeking cohort, control-case and review articles addressing the main risk factors associated with aggressive behavior pulled out from two electronic databases (Medline e SciELO).

## Results

Twelve assessment studies on risk factors associated with aggressive behavior (Table 1) were selected.[12-23] Of these, eight had adopted a prospective longitudinal study design,[12,14,15,18,19,21-23] three were case-control studies[16,17,20] and one was a transversal study.

Six studies related aggressive behavior to genic expression.[12-17] Two demonstrated the genic expression of the serotonin transporter,[13,14] one demonstrated the genic expression of the monoaminaoxidase (MAOA),[12] another study demonstrated the genic expression of the transporter and the receptor of dopamine,[15] and two studies presented the genic expression of the catechol-O-methyltransferase enzyme (COMT).[16,17]

Four studies related aggressive behavior to maternal exposure to psychoactive substances.[18-21] Two other studies showed evidence that the use of tobacco during pregnancy constitutes an important risk factor,[18,19] while one study demonstrated the role played by alcohol in this interaction.[20] Exposure to cocaine was also the object of one of the studies.[21] One study evaluated the effects of malnutrition during the first years of infancy[22] and another evaluated the impacts of neglect and abuse at infancy.[23] Finally, a review of the socio-environmental factors from a more qualitative perspective discussed how such factors interact with the development of aggressive behavior.

Next, we will discuss the factors contemplated in each of these studies.

## Genetic factors

Genetic studies conducted with twins and adopted individuals have found genetic substrates underlying the development of aggressive, antisocial and violent behavior. Approximately 50% of the variance found in the anti-social phenotypes can be traced back to genetic factors.[5,24] Genetic findings have implicated the genes associated to the expression of MAOA, as well as those involved in serotoninergic, noradrenergic and dopaminergic activities.

### 1. MAOA

Genetic studies have identified polymorphisms located at the promoter region of the gene involved in the MAOA genotype. The presence of four repetitions of alleles is related to the gene's high activity level i.e., to greater genetic expression while the presence of three repetitions is associated to a low activity level.[25-27]

In 2006, Widom et al. conducted a prospective study with 802 participants who had been subjected to abuse and neglect and were followed-up on until they reached adulthood.[12] In an attempt to understand the development of aggressive behavior throughout one's lifetime, this group was compared to a control group which had not been subjected to aggression during childhood. The MAOA genotypes of these individuals were also compared. The population was divided according to ethnicity i.e., Caucasians and non-Caucasians. The conclusion was that, in the presence of an adverse environment at infancy, Caucasians (beta = 0.27, $p < 0.01$) with low-activity genotypes had a higher the risk of suffering from behavioral problems throughout their lifetime. In children who suffered abuse at infancy, however, a higher expression level of MAOA was associated to a lower frequency of violent and antisocial behavior at adulthood, although no statistical significance could be established. This association could not be demonstrated among non-Caucasians in whom the genetic polymorphism seems to be less correlated to the gene's expression levels. The low activity of the MAOA genotype was not predictive of violent and antisocial behavior in the absence of abuse at infancy. Thus, the authors concluded that the MAOA genotype has a moderating effect on the impact of neglect and abuse suffered at infancy on the development of violent and antisocial behavior at adulthood. Other studies are in agreement with this hypothesis.[28,29]

2. Serotonin

Beitchman et al. evaluated the association of polymorphisms in the transporter gene of serotonin and aggressive behavior at both infancy and adolescence.[13] The sample was comprised of 82 individuals aged between 5 and 15 years who were genotyped for 5HTTLPR (n = 77) and 5HTT variable-number-tandem-repeat polymorphisms (n = 78). The presence of alleles with a low genic expression in the transcription control site in the serotonin transporter gene 5-HTTLPR (S/S, LG/S, Lg/Lg) was strongly associated to a risk twice as large of aggressiveness at infancy compared to individuals with high expression alleles (n = 77, p = 0.049, OR = 2.37, CI = 1.10-5.8). Similar results were shown by Haberstick et al., who conducted a prospective longitudinal study with a sample of 366 families with twin offspring that were followed- up on in a Longitudinal Twin Study (n = 1187).[14] The allele -S 5HTTLPR was associated to high levels of aggressive behavior in school-aged children (p = 0.0779). Other studies have established the same association with aggressiveness at adulthood,[30,31] thus leading to the conclusion that the presence of low expression alleles in adults is indeed associated with extreme violence.

3. Dopamine

Guo et al. conducted a study on the influence of the dopamine transporter gene (DAT1), which codifies the production of the dopamine transporter protein responsible for the uptake of dopamine in the synaptic cleft, and of the receptor gene (DRD2).[15] Based on a population sample of approximately 2,500 adolescents and young adults from the National Longitudinal Study of Adolescent Health, the authors concluded that the presence of 10 repetitions of 40 pairs of nitrogenous bases at region 3' doubles the risk of adolescents and young adults (p = 0.018) of becoming involved in violent and delinquent acts, while heterozygosis of DRD2 increases the risk by 20%, and homozygosis doubles the risk of the variation studied (p = 0.005).

Some of the studies investigated the relationship between the various polymorphisms in the dopamine receptor genes (DRD2 e DRD4) responsible for the production of receptors D2 and D4, respectively. Variations of the DRD2 gene as to the presence of alleles 1 or 2 and of seven repetitions in 48 pairs of nitrogenous bases in the DRD4 gene were investigated. The presence of allele 1 in the DRD2 gene proved to be associated with a higher risk of developing violent behavior in isolation[32] and in association with a variant of the DRD4 gene.[33,34] Individuals with isolated variations in the DRD4 gene did not present higher rates of violent behavior.[33]

4. COMT

Some of the studies investigated the presence of polymorphism in the COMT enzyme transcriptor gene. In a population of 353 individuals of which 180 suffered from schizophrenia and 173 were controls, Jones et al observed that patients who were homozygous for the polymorphism that determines the low activity level of the COMT gene presented significantly higher aggressiveness scores (OR = 2.07) when compared to heterozygous patients (OR = 0.54).[16] While also studying a population of schizophrenic patients who had committed homicide (n = 30), compared to non-violent schizophrenics (n = 62) and to a control group (n = 415) with regards to the presence of the valine or methionine alleles,[17] Kotler et al. did not find a statistically significant difference between non-violent schizophrenics and the control group, although in the homicidal schizophrenics, the frequency of the low activity COMT genotype (p = 0.087) was higher. The presence of the methionine allele is related to the gene's low activity which, in turn, is associated with a higher risk for the development of aggressive and antisocial behavior. The authors believe that the gene's low activity is related to deficits in the prefrontal cortex, thus reducing the control of aggressive impulses.[17]

Complications in the prenatal period and at birth

There are known associations between complications experienced during the prenatal period and at birth and the development of behavioral problems at infancy. The main factors include maternal exposure to alcohol, tobacco and cocaine during pregnancy, maternal malnutrition and hypoxia at birth. Brennan et al. carried out a longitudinal prospective study with a sample of 2,127 sons whose mothers had smoked tobacco during the third gestational trimester and who, as adults, had been arrested for perpetrating violent and non-violent crimes.[18] They concluded that intrauterine exposure to tobacco constitutes a marked risk factor for the development of an aggressive and antisocial behavior ($p < 0.001$). In a longitudinal prospective study comparing twins born to 467 mothers who had smoked during pregnancy and 898 twins born to mothers who had not smoked during pregnancy, Orlebeke et al.,[19] observed that smoking during pregnancy is strongly associated to the externalization of problems such as opposition, aggressiveness and hyperactivity. Animal studies have related the intrauterine exposure to tobacco to damages in the noradrenergic system, reduced levels of dopamine and serotonin, reduced levels of glucose in the brain, and lesions to the basal ganglions and the cerebral and cerebellar cortexes.[35,36]

Fetal exposure to alcohol can damage several brain structures, including the corpus callosum. Violent behavior has been associated to lesions to the corpus callosum. In a case-control study, Roebuck et al. studied two groups of children where the first group had been heavily exposed to alcohol (n = 32) during the intrauterine period, while the second group had not been exposed to alcohol (n = 32).[20] Children exposed to alcohol during pregnancy presented, more frequently, impairments in terms of cognition and psychosocial functioning such as loss of social abilities, increased hostility, impulsivity and emotional lability, as well as being more involved with delinquency (T-score = 76.28).

Delaney-Black et al. investigated the impact of fetal exposure to cocaine by associating this exposure to an increase in delinquency levels.[21] A longitudinal prospective study with 201 children who had been exposed to cocaine and 270 who had not been exposed concluded that the first group presented more intense externalizing and delinquent behaviors (p = 0.018), with young boys being more vulnerable. Because cocaine affects monoaminergic systems, intrauterine exposure interferes with the development of these system's circuitry. These studies, however, present certain limitations in terms of the samples used in that these included confounding variables used such as family environment where there was very little stimulation, poverty, maternal nutrition and the use of other drugs.[21,37]

**Table 1 – Methodological characteristics of and results from the studies that evaluated risk factors associated with aggressive behavior**

| Author | Year | Type of study | Sample | | Risk factor under study | Instrument | Result |
|---|---|---|---|---|---|---|---|
| | | | Size | Characterization | | | |
| Widom & Brzustowicz | 2006 | Longitudinal prospective | n = 806 (interviewees), n = 638 (blood samples), n = 631 (DNA analysis) | Children victimized by abuse and neglect | MAOA Genotype<br>Ethnicity (Caucasians and non-Caucasians) | Self Report | Low-activity genotypes increased the risk of conduct disorder during lifetime in the presence of an adverse childhood environment (in Caucasians, beta = 0.27, p < 0.01). |
| Beitchman et al. | 2006 | Longitudinal retrospective | n = 77 (genotyped 5HTTLPR), n = 78 (genotyped 5HTT variable-number-tandem-repeat polymorphisms | Children between 5 and 15 years of age showing clinically relevant aggressive behavior for at least two years | Genic expression of the 5HT gene transporter | Child Behavior Checklist<br>Teacher's Report Form | Genotypic variances with a low-expression for the polymorphism of 5HTTLPR was highly associated with aggressiveness at childhood. |
| Haberstick et al. | 2006 | Longitudinal prospective | n = 1.187, 366 families, n = 455 (parents), n = 382 (MZ), n = 350 (DZ) | Twins and parents who participated in the Longitudinal Twin Study (LTS) | Genic expression of the 5HT gene transporter | Child Behavior Checklist<br>Teacher's Report Form | Allele-S 5HTTLPR was associated with high levels of aggressive behavior in school-aged children. |
| Guo et al. | 2007 | Longitudinal prospective | n = 2.500 (sub-sample of the National Longitudinal Study of Adolescent Health | Adolescents and young adults involved in violent acts and delinquency | Dopamine (DAT1) and DRD2 gene transporter | Self Report | The presence of 10 repetitions of 40 pairs of bases at region 3' in adolescents and young adults was associated with stronger involvement with violent acts and delinquency. |
| Jones et al. | 2001 | Case-control | n = 180 (cases), n = 173 (controls) | Patients diagnosed with schizophrenia (DSM-IV) | Polymorphism of the Catecol-O-Metiltransferase (COMT) gene | Schedules for Clinical Assessment in Neuropsychiatry (SCAN)<br>Overt Aggression Scale (OAS) | Homozygotes presented significantly higher aggressiveness scores (Odds Ratio = 2.07) compared to homozygotes (OR = 0.54). |
| Roebuck et al. | 1999 | Case-control | n = 32 (cases), n = 32 (controls) | Children heavily exposed to alcohol during the intra-uterine period (19 children with Fetal Alcohol Syndrome) | Heavy exposure to alcohol during intra-uterine life | Personality Inventory for Children (PIC) | Children exposed to alcohol during their intra-uterine lives present significant cognitive and psychosocial functioning impairments, with increased hostility, impulsivity and lability and stronger involvement with delinquency (T-score = 76.28). |
| Liu et al. | 2004 | Longitudinal prospective | n = 1.795, n = 353 (malnourished at age 3) | Malnourished children at age 3 | Malnourishment at childhood | Children's Behavior Questionnaire<br>Revised Behavior Problem Checklist | There is a direct relationship between the level of malnutrition and the level of externalizing behavior (aggressiveness and hyperactivity) at 8 and 17 years of age. |
| Brennan et al. | 1999 | Longitudinal prospective | n = 4.169 (men) | Sons whose mothers smoked tobacco during the third trimester of pregnancy | Maternal exposure to tobacco during pregnancy | Danish National Criminal Register<br>Danish Psychiatric Register | There is a direct relationship between the use of tobacco used by the mother at the third trimester of pregnancy and the history of detentions of the offspring at adulthood for both violent and non-violent crimes. |
| Orlebeke et al. | 1997 | Longitudinal prospective | n = 1.365 | Twins born to mothers who smoked during pregnancy | Maternal exposure to tobacco during pregnancy | Child Behavioral Checklist for 2-3 years | Mothers who smoked tobacco during pregnancy had a strong effect on the so-called externalization of behavioral problems (opposition, aggressiveness, hyperactivity) |
| Singer et al. | 2002 | Longitudinal prospective | n = 415, n = 218 (exposed to cocaine), n = 197 (controls) | Children whose mothers used cocaine during pregnancy | Maternal exposure to cocaine during pregnancy | Bayley Mental and Motor Scales of Infant Development | After two years, children exposed to cocaine presented impaired development (mental development index < 80) (OR = 1.98; 95% confidence interval, 1.21-3.24; p = 0.006). |
| Delaney-Black et al. | 2000 | Longitudinal prospective | n = 471, n = 201 (exposed to cocaine), n = 270 (controls) | Children whose mothers used cocaine during pregnancy | Maternal exposure to cocaine during pregnancy | Teacher's Report Form | Children exposed to cocaine during the intra-uterine period presented a high level of externalization (aggressiveness and delinquency)/internalization (anxiety, depression, retractness, and somatic signs). Boys were two times more vulnerable than the controls with respect to the externalization scores (25% vs. 13%) and delinquency (22% vs.11%). |
| Kotch et al. | 2008 | Longitudinal prospective | n = 1318 | Children under risk for abuse and neglect | Neglect/abuse at early childhood (up to 2 years of age) and at late childhood (at 4, 6 and 8 years of age) | Child Behavior Checklist | Neglect at early childhood (up to the age of 2) is a strong predictor of aggressiveness. |

Intrauterine hypoxia or hypoxia at birth may damage various brain structures, including the hippocampus, which is involved in the control of aggressive behavior and appears to be the most sensitive. Complications at birth are now being associated with adult violent behavior when in combination with the presence of a hostile environment where there is, for example, early maternal rejection at infancy.[35] Maternal malnutrition characterized by a poor intake of proteins, if experienced at the first and second trimesters, has been associated with adult antisocial behavior.[35,38] Minor physical abnormalities at birth suggest poor neural development and may be associated with the delinquent and violent behavior seen in children and adolescents.[39]

### Childhood malnutrition

Liu et al. carried out a longitudinal prospective study to evaluate the association between malnutrition experienced until the age of 3 and aggressive behavior at ages 8, 11 and 17 in a cohort of 1,795 children of which 353 had experienced malnourishment at age 3. A direct association between the degree of malnutrition and externalizing behavior (aggressiveness and hyperactivity, $p = 0.04$ at 8 and 17 years of age), as well as a reduced intelligence coefficient, was observed.[22]

### Other findings

Other risk factors relating to aggressive behavior were identified during the selection process of the articles to be included in this review. Such studies were not selected and were, therefore, not listed in Table 1 either because their samples were not significant or because they were neither longitudinal nor statistically powerful studies. Although further studies are required, what follows next is a brief description of all the data collected which, in our opinion, seemed most relevant.

### 1. Neurological changes resulting in aggressive behavior

1) Dysfunctions of the frontal lobe

The frontal lobe is related to abilities such as making decisions, planning, proceeding with and giving continuance and coherence to one's acts, monitoring, making assessments, adjusting one's behavior according to internal and external drivers, modulating feelings and controlling an individual's behavior. It reaches full maturity at adolescence.[40]

The prefrontal region is associated with the control and regulation of emotions, reactions and impulses generated by the limbic system. Lesions to the prefrontal areas compromise the control of the subcortical areas, thus enhancing negative emotional reactions and violent behavior.

Neurophychopathological theories[41] have established a relationship between aggressive behavior and damages to 1) the prefrontal areas and its connections with the brain's subcortical areas and 2) the temporal areas associated with limbic structures. This damage could result in deficits in the executive functions of attention, concentration, memory and finer mental processes, in the wrong interpreting of both stimuli and adverse events, and in an inability to regulate impulses.[42,43]

Patients with frontal lesions display poorer emotional control and are less able to judge the impact of their behavior. They have difficulty in establishing empathy and conducting critical assessments of their dysfunctional behaviors, which they tend repeat.[41]

Ventral and orbital prefrontal lesions are associated with disinhibition, increased impulsiveness and greater predisposition to engage in violent behavior.[35] The earlier an individual suffers a lesion, the greater the impact on his or her internal controls. In both children and adolescents, traumatic lesions due to traumatic head injuries (TBIs), especially to the frontal regions are associated to increased aggressive behavior.[35] Structural and functional neuroimagining studies found slower glucose metabolism and activity rates in the prefrontal area of aggressors, as well as reduced prefrontal gray matter in antisocial individuals in the range of 11% when compared to controls.[44]

2) Dysfunctions of the temporal lobe

Lesions to the medial temporal lobe where the structures of the limbic system are located are associated with intermittent impulse control disorders characterized by episodes of extreme unprovoked anger, as well as with rather more disorganized and less directed aggressive behaviors. There may be memory and intellectual deficits, auditory and visual hallucinations, receptive language impairments, aggressiveness and reduced impulse control.[40]

3) Changes in neurotransmitters

Impulsive aggressive behavior is associated with an imbalance between the various neurotransmitter systems of the prefrontal cortex, especially that of the serotoninergic system, which is responsible for the regulation of the dopaminergic system. 5-HT2 receptors inhibit dopaminergic activity. In the prefrontal areas and anterior cingulum, serotoninnergic transmission controls emotions and behavioral responses; reduced serotoninergic activity is mainly related to impulsive aggressive behavior.[44,45] Antisocial individuals have low levels of serotonin metabolites, 5-HIAA and high levels of homovanillic acid, which is a metabolite of dopamine in the cerebral spinal fluid.[44] Animal studies have demonstrated that increased dopaminergic transmission in both the prefrontal cortex and the nucleus accumbens result in increased aggressiveness. The blocking of dopaminergic activity in humans reduces their ability to identify facial expressions of anger and decrease impulsivity-driven aggressiveness. In conclusion, reduced serotoninergic activity and increased dopaminergic activity are interconnected and associated with a higher risk of violent behavior.

4) Hormonal

High levels of testosterone are associated with aggressive behavior.[46,47] Women who have committed crimes tend to become more aggressive during their menstrual period. This can be attributed to the low estrogen levels that are typical of this period. High cortisol levels may be associated with persistent aggressive behavior in men.[48]

5) Nutritional

Nutritional deficiencies are risk factors for the development of aggressive behavior.[49] Studies have shown that animals on a tryptophan-poor diet presented high rates of aggressive behavior.[50] In children, zinc and/or iron deficiencies are also related to increased aggressive behavior[51,52] since iron deficiency may reduce dopaminergic transmission.

6) Intoxications

Intoxications with metals such lead, copper and zinc predispose individuals to increased violent aggressive behavior. There is evidence, however, that an increase in the availability of calcium in the diet of intoxicated patients may have a positive effect,[53] although this is still a preliminary result.

7) Gender

Aggressive behavior, especially of the more serious forms is more frequent in males. Some suggest that the reason why women do not manifest more aggressive forms of behavior is based on biological protection factors such as a larger corpus callosum, better inter-hemispheric communication, increased verbal ability and faster maturing of the frontal regions, thus promoting the development of cognitive and social abilities which, in turn, allow women to cope more easily with interpersonal problems. In addition to the biological gender differences, the fact that men are more exposed to environmental risk factors should be taken into account.[54]

### Socio-environmental factors

In a longitudinal study, Farrington et al. identified the following key social predictors of violent and aggressive behavior: poverty, family history of criminality, precarious upbringing, failing at school, attention deficit, and hyperactivity and antisocial behavior during childhood.[55]

In Brazil, Schraiber et al. studied the main determining socio-environmental factors leading to aggressive behavior. They reached the conclusion that socio-economic inequalities, low pay, low family income, the lack of comprehensive public policies to meet the health, education, housing and security needs of the general population, the priority given to economic development to the detriment of social development, and the strong consumption appeal in contrast with the country's impoverishment are associated with increased risk for the extremely aggressive kind of behavior seen in the case of homicides.[56] From a socio-environmental standpoint, more aggressive individuals have a deficit in processing social information i.e., their ability to process information, interpret and ponder the risks and benefits of his or her actions.[57] According to the socio-environmental theories, violence and aggressiveness are acquired. The social learning theory believes that children acquire values and norms from the social group to which they belong, and that they do so through their own experiences and by witnessing their groups' social behavior. If a child is properly rewarded or punished for its behavior, if it is given positive examples by its parents and if it doesn't witness family conflicts, then the child will be able to develop the cognitions and social skills required for interpreting social data, thus making it possible for the child to behave in an appropriate and non-violent fashion.[57,58] According to the social learning theory, the main risk factors for conduct disorder, aggressiveness, delinquency and crime are low levels of self-control and self-regulation and exposure to delinquent peers.[59,60]

Children that are either inconsistently punished or rewarded, who witness family conflicts or whose parent is involved in crime are unable to develop the skills required for coping with social problems. Parents are responsible for passing on the first batch of information that allows children to develop their social skills; children born to negligent parents that engage in erratic discipline, are in conflict with each other or commit crimes exhibit early criminal behavior which, in turn, can be attributed to the maintenance of such behavior during their lifetime.[35,55]

Forms of abuse at infancy such as maternal rejection, inter-parental violence, negligent parenting, repeated loss of the primary caregiver, severe or inconsistent discipline and sexual and physical abuse constitute risk factors for the development of violent behavior at infancy which, in turn, is predictive of offensive, aggressive and antisocial behavior in adults.[61-63] For example, in a longitudinal prospective study (n = 1318) (LONGSCAN), Kotch et al. identified early neglect as the most important kind of abuse at infancy and associated it to the development of aggressive behavior ($p < 0.01$).[23] Development theories that give special emphasis to the impact of early experiences such as the breaking of an infant's bond with his or her parental figure suggest that early forms of abuse suffered early in life may be stronger predictors of aggressive behavior than forms of abuse suffered later in life.[23]

Studies have shown that young people who have witness parental violence have a risk factor for getting involved in violent love relationships. Children exposed to violence use violence to solve their own conflicts. For example, victims of sexual abuse are twice as likely to experience at least one violent episode in their relationships.[64,65]

Teenagers who spend time with delinquent peers are more likely to behave in a delinquent fashion.[60] Their low level of self-control and strong impulsiveness, which may be mediated by genetic and environmental factors make them feel attracted to these groups and rejected by pro-social groups due to their limited verbal skills and their narrow pool of solutions to which they can resort to solve their social problems. Teenagers who are poorly attached to their mothers or whose parents are absent, poorly engaged or emotionally disconnected or, still, whose parents are overly permissive get more frequently involved with delinquency, the use of alcohol and drugs and are more likely to socialize with delinquent peers.

According to the social disintegration theory, another key point to the understanding of violent behavior is the failure on the part of social and community institutions in providing the resources needed to ensure basic needs, social acknowledgment and physical integrity.[65]

The three levels of social integration are the socio-structural level, i.e. access to material and cultural goods, the institutional level, i.e. power, and the socio-emotional level.[66] The more socially integrated the subject is, the easier it is for him or her to accept the social rules in place. The likelihood and intensity of violent behavior increase to the extent that the subject experiences fear of disintegration, which, in turn, decreases the subject's ability to control his or her violent behavior. Lack of social acknowledgement may be offset by violent actions because these help quieting feelings of weakness and enhance self-esteem. Violence is used as a means to restore justice or command respect and affirm one's identity.

The emotional stress experienced by the parents may cause the family to disintegrate, thus affecting the children's ability to socialize due to feelings of frustration and insecurity, as well as to tensions and conflicts. Children who grow up with a negative self-image are more likely to display aggressive tendencies. The presence of someone with whom the child may share his or her

concerns may, however, serve as a useful model for breaking the cycle of violence.[67]

### Interactions between the physical and biological environments

The development of social skills depends upon the interaction between biological development/maturation and environmental experiences. The acquisition of social cognitive skills is influenced by deficits in the frontal lobe and inter-hemispheric communication, socializing with both parents and peers and by verbal skills. Aggressive and antisocial individuals act on impulse, i.e. they do not think before they act, they have difficulties in abstracting and deficits in solving interpersonal cognitive problems, they are egotistical, show very little empathy and have difficulty in grasping what other people may be thinking or accepting the fact that other people may think differently.[57,68] These cognitive deficits may place the individual in a socially disadvantageous position, making him or her even more susceptible to respond aggressively and to become involved with crime. Because the environment can eliminate certain behaviors while rewarding others, it is possible for individuals who are biologically vulnerable to aggressive and antisocial behavior to acquire, through learning, a more adaptive behavior placed in a more stimulating environment. Genetic factors interact with environmental factors to produce aggressive behavior. Genetic polymorphism alone does not suffice to explain the development of a certain behavior; however, it might make it more likely for certain behaviors to appear.[69] As already mentioned, studies that have evaluated the impact of a polymorphism of the MAOA gene demonstrated that genetic influence on behavior is only seen in the presence of abuse at infancy.[12,28]

Ferguson developed an antisocial behavior model known as the catalyst model, according to which genetic factors and environmental effects such as exposure to family violence interact to produce a personality who is more inclined to behave extremely violently.[69] This model also claims that human beings have a system located in the frontal lobes that controls their impulses, thus inhibiting the expression of aggressive behaviors. Because failures in this system are strongly influenced by genetic factors (50% to 90% inheritance), a hostile and stressful environment - especially with respect to family members or caregivers serves as a catalyst for aggressive behavior in predisposed individuals.[5,60,69] Therefore, self-control and self-regulation are associated with genetic and social factors, i.e. socializing with parents, neighbors and schoolmates. Children who are raised in more favorable environments have more self-control. It can be concluded that biological and environmental factors act both independently and in association to produce antisocial and aggressive behavior.[28] A risky environment might aggravate existing biological deficits while protective environments might attenuate these same deficits.

## Conclusion

Several factors are involved in the development of aggressive behavior. Studies have provided evidence that biological and socio-environmental factors, as well as a combination of the two may be implicated in the development of aggressive, violent and antisocial behavior. According to the literature, more evidence has been gathered of the following biological risk factors: 1) genetic (low expression of the MAOA genotype in the serotonin transporter gene, polymorphism in the dopamine receptor genes i.e. DRD2 e DRD4 and in the dopamine transporter gene 2) complications experienced during the prenatal period (hypoxia, maternal malnutrition and exposure to alcohol and tobacco and 3) postnatal hypoxia, malnutrition at childhood and dysfunctions in the prefrontal cortex related to serotoninergic hypoactivity and dopaminergic hyperactivity resulting in the impairment of executive functions, ability to control oneself and inhibitory of the limbic system.

The socio-environmental factors that are most evident are related to the socio-environmental deficits present at childhood that compromise the development of cognitive skills which allow the child to identify and cope with social problems. The main impairment in terms of the learning process of social skills can be attributed to relationship problems with the child's parents. Children born to violent and negligent parents are unable to incorporate the values of their respective social groups. Moreover, it is worthwhile keeping in mind that these are not determining factors since there is always the possibility for the child of a violent parent to find in the person of another adult, at school or in other social network institutions the support it needs to find a way to insert itself other than through violence. It is also important to emphasize that this review did not search all databases, did not have the intention of identifying all the prospective studies available in the literature and, last but not least, did not attempt to aggregate results. Furthermore, with respect to the biological factors cited, this review assigned priority to quantitative studies while with regards to the socio-environmental factors, the main studies found were of a qualitative nature, except for the article that correlated early neglect in providing care and aggressive behavior. Nevertheless, we believe that the model that combines biological and socio-environmental factors is of a quantitative-qualitative nature. The study of aggressive behavior should not be based exclusively on one of these models because it is the combination of all the information that they provide that allows us to see this from a wider perspective, similarly to the study of the phenomenon of violence in our society.

The main conclusion of this review is that the interaction between biological and environmental factors may be catalyzed by a hostile environment, thus increasing the risk for the development of aggressive behaviors or, alternatively, that an environment favorable to one's development may attenuate unfavorable genetic characteristics, thus restraining the development of aggressiveness.[69]

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** Modest*
*** Significant*
**** Significant. Amounts given to the author's institution or to a colleague for research in which the author has participation, not directly to the author.*
*Note: UNIFESP = Universidade Federal de São Paulo; FAPESP = Fundação de Amparo à Pesquisa do Estado de São Paulo; CNPq = Conselho Nacional de Desenvolvimento Científico e Tecnológico.*
*For more information, see Instructions for authors.*

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