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Review Article

A REVIEW ON THE IMPACT OF THE ENVIRONMENTAL ADVERSITIES ON VARIOUS DEVELOPMENTAL DISORDERS OF BRAIN IN CHILDREN

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ABSTRACT

Scientific researches over the last 30 years in defining the role of various toxins and stresses during the utero and postnatal phase, malnutrition, brain injuries and selective food deficiencies have shown enough evidence of their role in neurodevelopmental disorders. The effect of environment on various developmental disorders such as Attention deficit hyperactivity disorder (ADHD), autism spectrum and learning disabilities has paved the way for better understanding of genetic influences. Several types of genetic and environmental adversities indicate that neurodevelopmental disorders suggest a causal role. There is marked variation in the susceptibility of individuals to these adversities. Thus their vulnerability to the disease could influence the extent they are prone to that disease. The aim of this review is to bring together various aspects of environmental factors and genetic susceptibilities and summarize their toxic effects towards neurodevelopment in children.

Keywords: ADHD, Autism, Learning disability, Neurodevelopmental disorders, Methyl mercury, Polychlorinated biphenyls.

INTRODUCTION

Neurodevelopmental disorders are the disabilities associated with the functioning of neurological system and brain. The examples of disorders are Attention deficit hyperactivity disorder (ADHD), Autism, Learning disabilities. The children susceptible to these disorders experience difficulties with the language, motor skills, behaviour, learning and memory.

Based on the parental exposure to the survey on neurodevelopmental disorders, it was found that majority of children suffer from ADHD and autism and the rate is increasing alarmingly over the last four decades[1-6].

Genetics play an important role in many neurodevelopmental disorders but most of the disorders have more than one cause. These disabilities are a combination of genetic, environmental, biological and psycho-social risk factors.

Environmental factors

Studies found that the environmental contaminants damage the child's developing brain and nervous system. There had been evidence regarding the childhood lead exposure added to learning problems and reduced cognitive development[7], ADHD [8] and hyperactivity and distractibility [9]. Furthermore lead exposure have been found detrimental in memory and planning [10, 11] causing impulsiveness in children [12].

Methyl Mercury

Children's neurological development has been negatively impacted by methyl mercury. In Japan and Iraq, prenatal exposure to particularly high levels of mercury was found to cause intellectual disability as well as impaired motor and sensory function [13, 14]. Mercury's more subtle effects were studies on island population of New Zealand and Faroe islands where frequent fish consumption by pregnant woman lead to mercury exposure. Results from such studies suggested that intelligence was impacted due to increased prenatal exposure which was linked to maternal fish consumption [15, 16] and functioning in the areas of language, attention and memory were also impacted[17-20].

Polychlorinated biphenyl's (PCB's)

Prenatal exposure of polychlorinated biphenyls has been linked to the neurodevelopmental effects in children including lowered intelligence and behavioural deficits such as inattention and impulsive behaviour [21-26]. PCB's exposure has also been linked to problems with learning and memory [21-27]. Chen and Rogan also studied the adverse effects on intelligence and behaviour found in women who were highly exposed to PCB's, chlorinated dibenzofurans and other pollutant mixtures prior to conception [28-30].

Metals

Adverse effects on neurological developments upon exposure to metals such as cadmium, arsenic and magnesium have been reported in few studies [9, 31].

In animal studies adverse effects on behaviour, learning and memory due to polybrominateddiphenyl ethers (PBDE's) were found [32-34]. Another risk factor for neurodevelopmental impairment is the disruption of the thyroid hormone levels in pregnant women caused by perchlorate, a naturally occurring man-made chemical used for manufacturing fireworks, explosives and rocket propellant [35-37].

The development process of child's brain begins shortly after conception and continues through adolescence, hence the brain of the child and nervous system are vulnerable to adverse effects from pollutant exposure. Even the slightest or the shortest exposure of the environmental contaminants can hamper the precise coordination of cell growth and movement if they occur at the critical developmental stages. Neurological deficits that arise from such disruption might have an effect on the child's achievements and behaviour even though it might not be a diagnosable disorder.

Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder (ADHD) is a disruptive behaviour disorder that not only diminishes academic performance but also makes family and peer relationships difficult and also reduces vocational achievements. ADHD is characterised by ongoing inattention or hyperactive-impulsivity occurring frequently in several settings than typical for other individuals in the same setting.

ADHD is diagnosed by observing the multiple symptoms of inattention or hyperactivity. Symptoms of ADHD vary in children where some display hyperactive behaviour traits and others display inattentive traits. Nigg explained that there is possibility of an individual's primary symptoms of ADHD to change as the age advances and inattentive behaviours are more likely to be displayed by adults [38]. Furthermore, Nigg also disclosed that children with ADHD often have other disorders such as learning disabilities and conduct disorders [38, 39].

Research on ADHD is rapidly expanding and many researchers have indicated through their work that ADHD is not only influenced by genetic factors but also by environmental factors. Epidemiological studies mostly published in 2006 have exposed the link of increased levels of lead in hair and blood, mercury in blood, phthalate metabolites in urine and the presence of chlorpyrifos (pesticides) in cord blood with increased likelihood of ADHD [8, 40-48].

Research carried to study the link between environmental contaminants and ADHD revealed that children diagnosed with ADHD have altered levels and activity of the neurotransmitter dopamine [49-54]. Exposure to lead, mercury, PCB's and pesticides have caused such an alteration of chemical activity in children and animals, thus emphasizing a potential cause of ADHD disorder [55-66].

Learning Disability

Learning disability is a neurological disorder that affects the ability of a child's brain to receive process, retain and respond to information. Although learning disability vary from child to child but commonly they may have trouble learning and using certain skills including understanding, inscription, paying attention, speaking, perception and doing mathematics. As per national dissemination centre for children with disabilities, children with learning disabilities are not unintelligent or unmotivated but there are differences in the way their brains process the information. Children with learning disabilities usually have average or above average intelligence [67]. Heredity may play a possible role of learning disability in a child. According to National centre for learning disabilities, problems during pregnancy and birth, low birth weight, use of drugs or alcohol during pregnancy, lack of oxygen or premature or prolonged labour may also be the contributing factor to learning disabilities [68]. There have been ongoing researches by various research bodies which show potential role of metals and other environmental contaminants in the development of learning disabilities.

Diagnoses of learning disabilities in children have been associated with elevated levels of lead in teeth and hair, cadmium in hair, magnesium in hair and dioxins and furans in blood [69-73]. Impaired memory, rule learning, difficulty following directions, planning verbal abilities and speech processing in children have been associated with exposure to lead [10, 74-79].Mercury has been linked to dysfunctions in children's language abilities and memory [18, 20]. Prenatal exposure of PCB's has been associated with poorer concentration and memory deficits in children with learning disabilities compared to unexposed children [21, 27].

Autism Spectrum disorders (ASD's)

Autism Spectrum disorders (ASD's) are a group of disabilities that cause significant social, communication and behavioural challenges. Spectrum disorders is a term associated with autism which explains the fact that although autistic people share common symptoms, the experience varies from mild to severe symptoms. Social adaptability is one common symptom shared by all children with ASD's. Lack of interest in other people resisting physical contact, trouble showing emotions or talking about feelings are the traits observed in children with ASD's. Children with ASD's have a range of communication problems. Some autistic children speak very well while other forty percent do not speak at all. Another distinguishable characteristic of ASD's is the demonstration of restrictive or repetitive interests or behaviours like repeating words more than once, lining up toys, rocking their bodies flapping hands or spinning in circles.

The combinations of multiple risk factors are likely to have caused ASD's and no single cause has been identified. Environmental contaminants may play an important role in causing ASD's. Hertz-Picciotto reported that in younger ages the increase in prevalence cannot be fully explained by diagnosis migration patterns, changes in diagnostic criteria and inclusion of milder cases[80]. Certain environmental chemicals are likely to affect the neurological signalling systems that are impaired in children with ASD's. Pessah reported that several pesticides interfere with Acetylcholine and Gamma amino butyric acid (GABA) neurotransmission, which are chemical messenger systems altered in certain subsets of autistic individual [81]. As reported by Kinney, several environmental contaminants have been identified that cause mutations in DNA and inhibit the body's normal ability to repair the DNA damage [82].

Mercury may play a possible role in the development of ASD's. High levels of mercury have been found in the blood, baby teeth and urine of children with ASD's when compared with control children in earlier studies [83-85], however recent studies found no such difference in children with ASD's and typically developing children [86]. A study conducted in Texas showed that increased autism prevalence was linked to the proximity of industrial and power plant sources of environmental mercury [87]. Lastly, a study of indoor environments like polyvinyl chloride flooring which contain phthalates have been found to increase the risk of ASD's in children [88].

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