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Lead Poisoning and Related Antisocial behaviors in Urban Environments: A Review

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Abstract

Lead is one of the most common toxic metals in our inner city environments. It is found almost in all aspects of urban environment and in biological systems including human. It affects nearly every system of the body and is particularly a problem for young children. Some of our urban crime can be traced to environmental pollutions. They may be associated with brain damage due to lead toxicity. Lead concentrations above the levels known to cause physical damage may be associated with an increased potential for antisocial, aggression and criminal behaviors in children and youth.

Lead toxicity has cultural, political and sociological implications and is one of several powerful biological and environmental factors that affect adult crime, violence, behavioral disorders, low school achievement, hyperactivity, and low levels of parental education. Future epidemiological studies of the causes of criminality should include lead and other neurotoxic agents as risk factors. In this paper the impact of lead poisoning on urban dweller's behavior, especially among children and youth are evaluated.

Keywords: criminal behavior, hyperactivity, Lead poisoning, violence.

1-Introduction

Lead toxicity, seems to have been a problem for a long time and it is one of the oldest established poisons. Since ancient times, lead poisoning has affected millions of people, both in developed and developing countries (Olympio et al., 2010). About 2,000 years ago, the Roman Empire produced and used tremendous amount of lead for a period of several hundred years. It has been argued that lead poisoning among the upper class in Rome was partly responsible for Rome's decline. Lead poisoning probably results in widespread stillbirths, deformities, and brain damage. Studies analyzing the lead content of bones of ancient Romans tend to support this hypothesis (Hong et al., 1996). Measurements of the concentration of lead from glacial ice cores show that during the Roman period, lead concentration in the glacial ice are about four times higher than before and after this period. This suggests that the mining and smelting of lead in the Roman Empire added small particles of lead to the atmosphere that eventually settled out in the glaciers of Greenland (Hong et al., 1994).

Although early case studies identified severe behavior problems as prominent outcomes of lead poisoning, epidemiological studies have only recently begun to focus in detail on psychopathological outcomes (Bellinger, 2008). Three meta-analyses confirmed that low level lead exposure was associated with reduced IQ (Schwartz, 1994). More recent data

indicated cognition, attention and behavior disturbances in children presenting lead levels in the order of 3–5 μg/dl (Chiodo et al., 2007).

Lead is not an essential trace element in any organism and has no known biological function, but it is sufficiently concentrated in the blood and bones of children living in inner cities to cause health and behavior problems. Lead affects nearly every system of the body (Botkin and Keller, 2005) and is long known as a devastating neurotoxicant (Thomson and Parry, 2006). Lead has been determined by many health experts to be the first threat to developing children in our industrial societies. More than one million children in the United States have blood lead levels above 10 μg/dl and are at risk of permanent neurological impairment. Because of its many uses, lead is now a common contaminant in waste site appearing in over half of the US Superfund sites. More than one million workers in 100 occupations are exposed to lead (ATSDR, 1992). Even low levels of lead exposure are associated with adverse health effects (Prasad, 2008).

2-Methodology

This research is based on the results of many recent studies conducted all over the world on lead poisoning contributed by many different disciplines. After reviewing sources of lead in the environment, specially its concentrations in urban environments, and based on different environmental effects of lead poisoning on living organisms (such as carcinogenic, behavioral, and social /legal effects), reported lead poisoning were then evaluated. Finally the preventive strategies for lead poisoning with more emphasis on criminal behavior of affected people and health impacts of lead are discussed and some concluding remarks are made.

3-Sources of Lead in human environment

Elevated blood lead can be due to many exposure pathways. It is a ubiquitous and insidious toxicant present not only in air, dust, water, soil, food, paints, car batteries, and gasoline, but also hidden in ceramic dishes, crystal baby bottles, toys, herbal medicines and eye makeup (Olympio et al, 2010). Lead in paint and gasoline had especially pervasive effects due to contaminated dust ingested via normal hand-to-mouth activity as children crawl (OECD, 1993). Lead exposure is a great problem in many developing countries, some of which still have leaded gasoline. Lead is still found in many old homes as a result of use of leaded paints. The soils along major roads still contain the lead that was emitted from automobiles and trucks in the past. Poor people and minorities more commonly live near hazardous waste sites, which results in exposure to a variety of hazardous chemicals. Children and pregnant women are also exposed to occupational and secondary lead exposure as for example; lead dust brought home on work clothes, lead in drinking water, industrial emissions, lead contaminated waste sites, ceramics, and home remedies and cosmetics in some nations (Rapuano and Florini, 1994). Atmospheric emissions affects blood lead even in rural areas, but traffic caused more severe city exposure as 55% of emissions settled within 20 km of roadways (OECD, 1993).

Lead in drinking water is considered to be a bioavailable source of lead because soluble lead is more readily absorbed in the intestine than lead from dietary sources. Control of lead exposure through drinking water should therefore be placed in any overall scheme of reduction (Hayes, 2010).

4-Lead poisoning

4-1. Lead poisoning and health

The EPA classified lead and lead compounds (inorganic) as probable human carcinogens. It is suggested that lead exposure can interfere with repair of DNA damage caused by

other chemicals. Lead acetate and lead phosphate cause kidney tumors in mice and rats (Hayes, 1997). As in the case of other heavy metals, one of the essential problems that are produced is the competence of the heavy metals with the nutrients, especially with the ones that share a certain chemical similarity. In this case, Pb and Ca have shown competence. This, for instance, has been shown very recently when lead toxicity was reduced by supplementation with calcium in mice (Prasanthi and Reddy.2006). The U.S. CDC have determined that blood Pb levels of 10 mg/dl should prompt public health actions, however recent studies in humans and animals have shown that the neurotoxic effects of Pb occurs at even lower blood Pb levels (Gilbert and Weiss, 2006). Low level Pb exposure is a risk factor for learning disabilities and attention deficit hyperactivity disorder (ADHD) (Braun et al., 2006). Many children with these behavioral syndromes also demonstrate deficits in auditory temporal processing, suggesting a disturbing link between developmental Pb exposure, behavioral dysfunction and auditory temporal processing (Prins et al, 2010). The relationship between blood lead burden and adverse health effects is illustrated in Table 1 from a range of case studies and related literature sources given in the table. Perhaps the greatest health concern associated with lead is reduced IQ in infants (Hayes, 2010).

Blood lead burden (µg/dl)	Reported adverse health effect	Source
Maternal levels >15	Associated with reduced birth weight	Dietrich et al. (1987)
12 to 120	Vitamin D metabolism interference	Mahaffey et al. (1982)
Increase from 10 to 20	Reduction in IQ by 3 points	Tong et al. (1996)
Increase from 10 to 20	Reduction in IQ by 1 to 2 points	Pocock et al. (1994)
Increase from 1 to 10	Reduction in IQ by 7.4 points	Canfield et al. (2003)
20 µg/dl	Increased hearing threshold compared to 4 µg/dl	Schwartz and Otto (1987)
Greater than 37	Hypertension	Pocock et al. (1984)
40 to 50 µg/dl	Decreased sperm counts	Assennato et al. (1987)
40 to 120 µg/dl	A range of neurological and behavioral effects	Agency for Toxic Substances and Disease Registry (2007)

Table 1.Blood lead burden and reported adverse health effects (Reproduced from Hayes, 2010)

WHO has progressively tightened its guideline value for lead from a maximum allowable concentration of 0.1 mg/l to the current 0.01 mg/l. The WHO Guidelines recognize that lead is exceptional, and that most lead in drinking water arises from plumbing and the remedy consists principally of removing plumbing and fittings containing lead. (Hayes, 2010).

4-2. Lead poisoning and Lower intelligence

Following acute toxic response to lead, some children manifest aggressive, difficult to manage behavior (Botkin and Keller, 2005). Lead appears to affect not only cognitive development of young children but also other areas of neuropsychological function. Young children exposed to lead may exhibit mental retardation, learning difficulties, shortened attention spans (ADHD), increased behavioral problems, and reduced physical growth (ATSDR, 1990). In 1979 Needleman et al. first clearly demonstrated that children exposed to lead early in life suffered a reduced IQ. Increased childhood intelligence has been found to be associated with a significantly reduced risk of generalized anxiety disorder (Martin et al., 2007).

4-3. Lead poisoning and violent crime

More than 50 years ago, clinicians reported a high prevalence of severe behavior problems in a series of schoolchildren who survived acute Pb encephalopathy (Dietrich, 2001). Recently, Bellinger (2008) pointed out that, "from a public health standpoint, there is a major concern of a possible "silent pandemic" of neurodevelopmental disorders resulting from children's continued exposure to low lead levels" (Grandjean and Landrigan, 2006). The form in which neurodevelopmental toxicity is expressed depends on factors such as: age at exposure, coexposure to other neurotoxicants, nutritional status, genotype and the characteristics of the home environment (Weiss and Bellinger, 2006). Lead exposure may preferentially inhibit functioning in several areas of the brain (Liu, 2011). More recently, brain imaging studies show that exposure to lead during childhood is associated with decreased gray matter volume in adulthood, especially in portions of the prefrontal cortex which are responsible for mood regulation and decision making (Cecil et al., 2008), which in turn predisposes these individuals to violent and criminal behavior. Consequently, lead exposure has been associated with outcomes related to poor impulse control, including violent offending, substance use, and ADHD (Bellinger, 2008). Many studies have reported that children with elevated bone lead levels showed higher aggression and delinquency scores compared to low lead counterparts and that elevated blood lead concentrations during the prenatal and postnatal are associated with higher rates of criminal arrests in early adulthood (Needleman et al. ;1996 and 2002, Burns et al.; 1999, Dietrich et al.; 2001, Wright et al.; 2008, Carpenter and Nevin, 2010, Liu; 2011). In addition, even children with low lead exposure may suffer from impaired cognitive performance (Koller et al., 2004).

Nevin (2000) has analyzed historic US rates of violent crime and related the changes in rates over time to the use of lead in gasoline (Fig. 1 &2). Preschool blood lead trends also appear to explain most of the substantial variation in property and violent crime rates in many developed countries across several decades. Crime rates track blood lead with similar time lags within each nation, consistent with neurobehavioral damage in the first year of life: A 23 year lag for violent crime, consistent with the typical age of violent offenders, and an 18 year best fit lag for burglary, consistent with the typical age of property crime offenders. The same time lag within each nation appears to explain divergent crime trends across nations (Nevin, 2007).

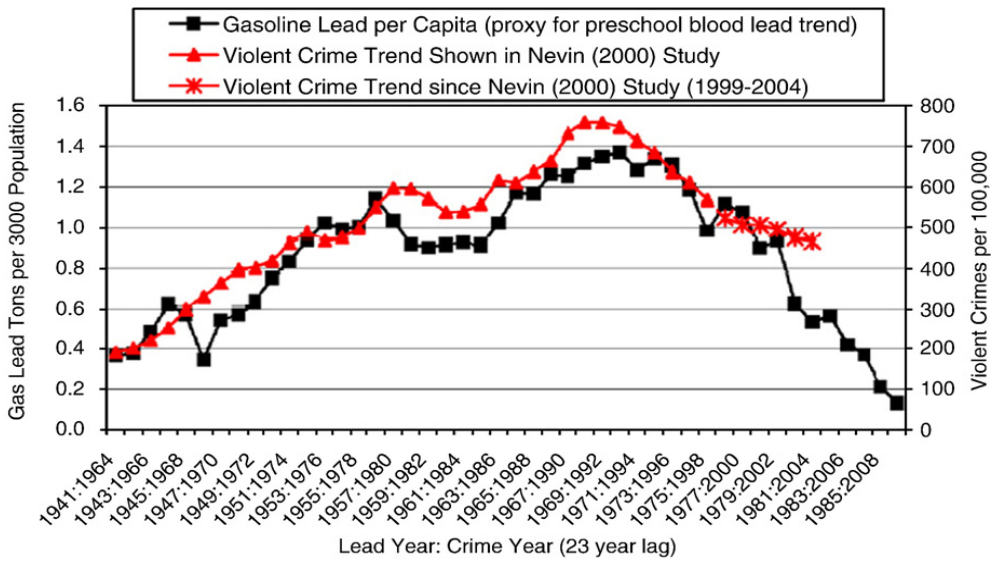

Fig. 1 USA violent crime and lead exposure trends. Gasoline lead per capita (left axis) and violent crime rates per 100,000 (right axis) are plotted against time, with the crime rate shifted for a 23 year lag (Reproduced from Nevin, 2007).

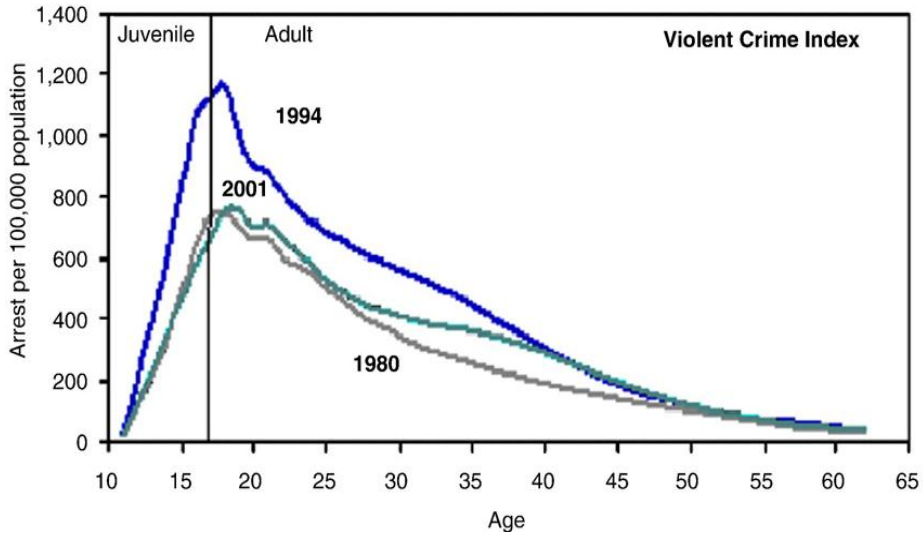

Fig. 2 USA age specific violent crime arrest rate shows that the peak offending age shifted to older ages by 2001, as the 1990s violent crime decline was associated with an especially sharp decline among juveniles born after the early 1980s decline in gas lead levels. (Reproduced from Nevin, 2007).

4-4. Lead poisoning and social and legal implications

There is the widespread belief that criminal behavior is the result of character defects and willful voluntary actions for which society does not approve. At least one factor leading to criminal behavior is early life exposure to chemical contaminants that cause irreversible alteration in brain function and behavior, making the individual more likely to take risks and less able to deal with the frustrations of life. In this regard crime may really be an epidemic, but an epidemic caused by high exposure of a significant fraction of the population to dangerous environmental chemicals. There is without question clear evidence that criminal behavior is more common in populations that are poor, often are minority, often individuals who grew up in inner cities where housing and education are below the standards found in suburban communities. The point is that these are also the areas which are more contaminated, leading to exposure to contaminants associated with reduced IQ and behavioral changes (Carpenter and Nevin, 2010).

5-Preventive strategies

Temporal trends in rates of violent crime in many nations are consistent with earlier preschool blood lead trends, with a lag of about 20 years. These ecologic correlations are consistent with many controlled studies suggesting that lead exposed children suffer irreversible brain alterations that make them more likely to commit violent crimes as young adults. If this pattern is true for lead and other contaminants, the most effective way to fight crime may be to prevent exposure to these contaminants (Carpenter and Nevin, 2010). Use of public health prevention programs may be particularly well suited to the early childhood developmental period. Tremblay's research on the prevention of criminal behavior, in which he characterizes the preschool years as being “the best window of opportunity” for successfully intervening to reduce physical aggression (Tremblay, 2010) and that the association between crime and preschool blood lead should lend urgency to

global efforts to eliminate preschool lead exposure (Rapuano and Florini, 1994). The CDCP recommends family education for children with elevated blood lead levels and community education for those living in areas with a high prevalence of elevated blood lead level (CDCP, 1997). As a prevention strategy, education can, in theory, teach parents of children how to minimize their children's future lead exposures through various preventive actions. Although empirical evidence linking preventive actions to lowered blood lead levels is scant, most prevention strategies have obvious potential to decrease children's lead ingestion or absorption (Campbell and Osterhoudt, 2000). Typical lead poisoning prevention programs emphasize housecleaning to remove lead contaminated dust, good nutrition, and regular hand washing (Endres et al., 2002). In areas with soil contamination, preventive messages also urge parents not to allow their children to play in soil or dirt that may contain lead (Pueschel et al., 1996). Routine blood lead screening is also encouraged to detect elevated blood lead levels early to ensure that actions can be taken to minimize future exposures (Kessel and O'Connor, 1997).

6-Conclusion

The evidence presented above indicates that at least some criminal and anti-social behavior is secondary to exposure to chemicals during the period of life when the brain is developing. While SES, genes, poverty, low IQ and other factors have been widely discussed in relation to violent behavior, there has been little, and totally inadequate, attention given to the role of early life environmental exposures. The very possibility that early life exposure to environmental contaminants predisposes to a life of violence and other criminal offending raises difficult ethical and legal questions. There is without question clear evidence that criminal behavior is more common in populations that are poor, often are minority, often individuals who grew up in inner cities where housing and education are below the standards found in suburban communities. The point is that these are also the areas which are more contaminated, leading to exposure to contaminants associated with reduced IQ and behavioral changes. Information on contaminants and criminal behavior is currently only available for lead exposure, but for all of the reasons discussed above we hypothesize that further study will show similar effects of the other contaminants that act to shorten attention span and decrease ability to deal with frustration. The action level for blood lead in the United States, used in the prevention of lead poisoning in children, is l0 mg/dl, although it has recently been suggested that it should be lowered to2 mg/dl as this lower level can be measured accurately and would encourage further action to reduce childhood lead exposure. The voluminous scientific evidence presented to date on adverse biochemical, medical, social, and economical losses linked to lead exposure and poisoning is firmly established and thus reliable to justify radical and urgent education and legal actions.

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