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Toxins, Brain Chemistry, and Behavior

I. The Problem

During the last two decades, evidence has accumulated that the interaction of environmental pollution, poor diet, and lifestyle contributes to the exceptionally high rates of violent crime in many American cities. Lead intoxication, even at low levels, correlates with aggressive behavior as well as learning disabilities. Manganese, a toxin that at high levels of exposure contributes to Parkinsonism, has also been linked to violent behavior. Effects of lead and manganese interact, moreover, so that individuals exposed to both show stronger effects than those exposed to either one alone. Alcohol and drug use, often associated with violent crime, increase the deleterious effects of toxic metals through complex biochemical interactions at the cellular level. These chemicals compromise the serotonin, dopamine, and other neurotransmitter systems that are integral to self-control due to their effects in lowering thresholds for violent behavior.

Environmental pollution does not impact everyone equally. Brain cells absorb toxic metals when diets are low in calcium, iron, zinc, Vitamin D, and other essential nutrients. Prenatal exposure to lead and alcohol can result in premature or low weight births, small head circumferences and learning or behavioral deficits. Bottle-feeding with commercial formulas exposes infants to four or five times as much manganese uptake as breast milk, a finding that suggests why studies show breast fed infants have IQ scores 2 to 8 points higher than comparable babies fed infant formula. In addition to direct effects of poor diet on children's behavior, nutritional deficits thus probably combine with exposure to toxic metals to increase the likelihood of attention deficit disorder (ADD), hyperactivity, and other learning deficits. In addition, because the problems of poverty and broken families often co-vary with inadequate diet, housing with lead paint, and aging water systems, as well as inadequate prenatal health care, high rates of bottle feeding, and exposure to industrial pollution, poor urban populations are at risk for neurotoxicity in multiple ways.

The neurotoxicity hypothesis is strongly grounded in findings from a number of laboratory studies and observations of human behavior. In seven different groups of prison inmates, violent criminals had substantially higher levels of lead or manganese in their hair than nonviolent criminals or law-abiding controls. Otherwise puzzling geographical differences in rates of violent crime in the U.S. are highly correlated with environmental pollution and death rates from alcoholism. Counties in which the EPA did not report industrial releases of either lead or manganese, and where alcoholism was lower than average, had a rate of 228 violent crimes per 100,000 people (well under the national average). In contrast, counties with industrial releases of lead and manganese and higher than average alcoholism had rates of violent crime of 969 per 100,000 (three times above the national average). (The statistics linking differences in the rate of violent crime to lead, to manganese, and to alcoholism would each occur by chance less than once per 10,000 times.) Controlling for 17 other factors, including population density, poverty, and ethnic composition, the three sources of neurotoxicity are significantly associated with violent crime.

II. Current Research

With the support of a grant from the Environmental Protection Agency, current work is exploring a number of ways that toxic pollution affects the public. Data from a number of surveys of children's blood lead are being combined with socio-economic and demographic data from the U.S. Census Bureau, health data from the Center of Disease Control, pollution data from the EPA, and crime data from the FBI. Our research will focus on the extent to which lead is being absorbed by humans due to: a) water treatment procedures; b) industrial releases of lead and other toxins; c) plumbing systems, leaded paint, and other sources of lead associated with old housing; d) other sources, such as lead residues in soil, that are particularly common in the center

of some American cities; and e) dietary habits (such as shortages of calcium and iron) and demographic factors (such as poverty, stress, and minority ethnicity) which are known to be associated with increased risk of lead uptake. The resulting geographical variations in lead levels in children's blood will also be studied as a factor that might explain rates of crime, educational failure and disease that are unusually high.

We are also studying "risk co-factors" that make lead and other toxic metals in the environment more dangerous to local residents. Here our emphasis will be on the use of silicofluorides as agents in water treatment. There are two reasons for this focus. First, both fluosilicic acid and sodium silicofluoride are toxins -- and both leave potentially toxic residues if they do not dissociate completely. In studying the correlations between the use of these chemicals and crime, disease, and behavioral dysfunction, we seek to establish clearly whether or not these compounds are poisoning the public. Second, the silicofluorides apparently function to increase the cellular uptake of lead and other toxic metals, such as manganese; confirming correlations between silicofluorides and lead uptake should thus clarify the extent to which these compounds are risk co-factors for toxicity and other hazardous effects.

III. Results to date.

Our analysis of data from Massachusetts has revealed several important findings which are confirmed, where evidence is available, by preliminary analyses of the 129 cities covered in the September 1992 EPA News Release and of county data in West Virginia.

1. Communities with a higher percentage of children having blood lead over 10 mg/dL are significantly more likely to have higher rates of violent crime and higher rates of educational failure.

2. Communities using either fluosilicic acid (H_2SiF_6) or sodium silicofluoride ($NaSiF_6$) have significantly higher rates of crime than those using sodium fluoride or delivering unfluoridated water (with the exception of towns with naturally fluoridated water).

3. The use of fluosilicic acid (H_2SiF_6) to fluoridate public water supplies significantly increases the amounts of lead in the water (whereas the use of sodium silicofluoride ($NaSiF_6$) or sodium fluoride (NaF) does not.

4. There is no linear relationship between the amount of lead in a community's public water supply (as measured by current methods of determining "90th percentile first draw water lead") and the rates of violent or property crime.

IV. Implications

If these research hypotheses are confirmed, it should be possible to target both criminal and civil environmental enforcement strategies in a way that produces major public health benefits by reducing exposure and absorption of lead pollution and thereby reducing violent crime, learning disorders. and such diseases as hypertension. In the past, questions have been raised about the need to regulate industrial releases of lead and some have doubted that chronic exposure to low levels of lead pollution actually harm humans. Other efforts, such as the removal of leaded paint from old houses, have also been subjected to criticism on the grounds that they actually release more lead into the environment. If the hypotheses tested in this study are confirmed, efforts to remove lead from the environment will be validated and their effectiveness improved. In addition, this study may also suggest some relatively inexpensive non-enforcement interventions, such as ending or modifying water fluoridation procedures using silicofluorides. For all these reasons,

environmental protection will be greatly enhanced by the acquisition of more comprehensive evidence of how environmental sources of lead and the risk co-factors for lead uptake are correlated with disease, crime, and behavioral dysfunction. The neurotoxicity hypothesis implies the benefits of a biomedical and dietary approach to educational failure, crime, and social deviance. Studies show IQ increases of as much as 15 points among children with poor diets who are given vitamin supplements. Removal of lead ("chelation") and other methods of biochemical normalization have also been found to improve behavior and learning. Other studies indicate that the successes of Head Start are due in good part to its nutritional component. Because many children do not continue to benefit from balanced diets after Head Start, poor nutrition may explain the frequently observed declines in educational performance after these programs have been completed. Interventions such as good neonatal care, breast-feeding, vitamin supplements, and school lunches might therefore improve educational performance, as well as reduce violence and social disintegration.

The neurotoxicity hypothesis provides a new and potentially crucial dimension to accepted theories of crime. Factors like poverty, population density, social disintegration, race, easy access to guns, and violence on TV are obviously important contributors to violence, yet they do not effect everyone the same way. Studies of the behavioral impact of heavy metals can increase our knowledge of why these factors influence some individuals more than others. Crime prevention, better systems for screening prison inmates for potential violence, and cost-effective parole or probation options are all attractive. At the same time, the implications of the neurotoxicity hypothesis for our social, education, and legal systems are enormous. This approach does not excuse crime on the grounds of biochemistry. If poor diet and alcoholism contribute to learning disabilities and crime, this information ought to have the same status as knowing that drinking and driving do not mix. Given advances in neuroscience, dare we ignore the behavioral effects of neurotoxicity when this knowledge promises more effective crime prevention -- and perhaps also more effective rehabilitation -- than current methods?