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Children's environmental health -- the study and prevention of disease and disabilities in children from exposures to social, physical, biologic, and chemical agents -- has emerged as a new field of research, policy, and clinical practice (Landrigan et al. 1998). The growth of this field has been fueled by the emergence of new morbidities in children, research showing that the fetus and child are particularly vulnerable to environmental influences, and mounting evidence implicating environmental exposures as major risk factors for prevalent diseases and disabilities in children (Lanphear, 2005).

One in six American children have a developmental problem, from a subtle learning disability to overt behavioral disorders, such as attention deficit hyperactivity disorder (ADHD) or autism (Boyle et al. 1994; Hertz-Picciotto, 2009). These conditions can severely impair a child's ability to succeed in school, elevate their risk for violent and criminal behaviors, and dramatically diminish their ability to contribute to society.

The findings from some of the most thoroughly studied and widely dispersed environmental toxicants indicate that exposure to exceedingly low levels are risk factors for the "new morbidities" of childhood -- intellectual impairments, behavioral problems, asthma and preterm birth (Lanphear, 2005). Indeed, there is often no apparent threshold and, in some cases the effects appear to be greater at the lowest levels of exposure (England et al. 2001; Canfield et al. 2003; Lanphear et al. 2005; Yolton et al. 2005).

Exposures to established environmental toxicants -- such as lead, tobacco, PCBs and mercury -- have consistently been linked with higher rates of intellectual impairment or behavioral problems, such as conduct disorder and ADHD (Needleman et al. 1990; Schantz et al. 2003; Kahn et al. 2003; Wakschlag et al. 2002; Stewart et al. 2003; Needleman et al. 1979; Lanphear et al. 2005; Yolton et al. 2005). There is emerging evidence that a whole host of new environmental chemicals – such as Bisphenol A, PBDEs, pesticides, phthalates, and airborne pollutants – are associated with intellectual deficits or behavioral problems in children, but the evidence is not as conclusive (Rauh, 2006; Engel, 2010; Eskenazi, 2007; Braun, 2009; Perera 2009; Herbstman, 2010). Much of this research was done by the NIEHS/US EPA Children's Environmental Health Research Centers working collaboratively with the Centers for Disease Control and Prevention.

Children's developing brains are more vulnerable to certain toxicants and pollutants than adults. The central nervous systems of the fetus and young child, which are undergoing rapid changes, are particularly vulnerable to some toxicants. The fetus is a recipient of toxicants through placental transfer (Perera et al. 2003; Whyatt and Perera 1995; Bearer 2003). In some cases, such as mercury, the fetus is exposed to a larger dose than the mother (Ramirez et al. 2000). In other cases, such as organophosphate pesticides, the fetus may lack critical enzymes to metabolize environmental toxicants (Chen et al. 2003). Toddlers are often at greater risk for exposure to many environmental toxicants because they have a high degree of hand-to-mouth activity and they absorb some toxicants more efficiently (Bearer 1995).

Biomarkers are revolutionizing our ability to study the impact of environmental chemicals on neurodevelopmental disabilities (Perera, 1997; Lanphear and Bearer 2005; CDC 2003; Sexton et al. 2004). Historically, scientists and clinicians relied on indirect markers -- housing condition, poverty, questionnaires, and community-level monitoring of water and air -- to quantify the effect of environmental influences on children's health (Sexton et al. 2004). Biomarkers are making it possible to directly measure the internal dose for many environmental chemicals and test causal associations of environmental exposures with disease and disability in children.

I wanted to share some of the results of the Cincinnati Children's Environmental Health Center to highlight the impact of low-level toxicity on children. In a 2003 study, published in the *New England Journal of Medicine*, we estimated that an increase in blood levels from <1 μg/dL to 10 μg/dL was associated with a 7 IQ point decrease (Canfield, 2003). Because of the policy implications, we convened an international group of experts to conduct a pooled analysis of seven cohort studies. We estimated that an increase in blood levels from <1 μg/dL to 10 μg/dL was associated with a 6 IQ point decrement (Lanphear, 2005). These studies have been confirmed by over ten studies conducted around the world.

We also confirmed earlier reports implicating childhood lead exposure in the epigenesis of psychopathology in children. We estimated that one in five cases of ADHD in US children were due to childhood lead exposure (Froehlich, 2009). We also found joint effects of prenatal tobacco exposure and childhood lead exposure. Although each toxicant was associated with a 2.5-fold elevated risk for ADHD, children with higher exposures to both toxicants had a 8-fold elevated risk for ADHD (Froehlich, 2009).

Finally, we confirmed that childhood lead exposure is a risk factor for criminal arrests in young adults. We found that lead exposure is associated with conduct disorder, criminal arrest and impaired brain development using magnetic brain imaging (Braun, 2008; Cecil 2008; Wright, 2008; Brubaker 2009). These and other studies suggest that much of the criminal and violent behaviors in the US can be attributed to lead toxicity (Nevin, 2000; Reyes, 2007).

Gould used these studies to conduct a cost-benefit analysis of lead toxicity. She estimated that for every dollar spent to reduce lead exposure, society would benefit by $17 to $220, a net annual benefit of $30 billion to $44 billion (Gould, 2009).

Over the past century, increasing evidence has emerged linking chronic, low-level exposure to environmental influences and industrial pollutants with many of the most prevalent and disabling learning and behavioral problems in children. But questions remain. It is critical, for example, to examine the interactions of multiple environmental toxins or pollutants and to identify how genetic susceptibility or other markers of susceptibility elevate the risk for disease or disability. It is critical to discern whether the new chemicals are risk factors for autism and other emerging behavioral problems in children. Funding that is directed to children's environmental health research – the Children's Environmental Health Centers, the National Children's Study and other research awards -- offers us the opportunity to resolve many of the unanswered questions and prevent some of the most serious problems that impact children's learning abilities and behavioral problems, but much more needs to be done.

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