Adverse Health Effects amongst Pediatric Population from Environmental Toxins

Brittney M. Cifarelli
Faculty Mentor: Anita N. Lee, D.P.E.
Department of Health Sciences, Eastern Connecticut State University

Introduction

Elevated levels of exposure to environmental toxins can threaten the developmental health of the pediatric population. Exposure to environmental toxins have been linked with higher rates of mental retardation, intellectual impairment, and behavioral problems (Needleman et al., 1990). The impact of known toxins is historic and widespread, causing death and adverse health effects amongst individuals across the world. A lead poisoning in paint epidemic surfaced in Queensland, Australia in the early 1900s (Lanphear, 2015). Children presented with anemia, paralysis of the lower limbs, blindness and death. Children with high blood lead concentration levels also had a greater chance of developing cognitive disabilities (Needleman et al., 1990). Later, in the 1950s, pregnant mothers consumed high levels of mercury-contaminated fish, which resulted in their newborns suffering from severe motor dysfunction and mental retardation in a Japanese fishing village (Harada, 1995). In 1955, children were ingesting arsenic-contaminated powdered milk, initiating more than 12,000 cases of arsenic poisoning, resulting in exposed children to be 10 times more likely to suffer from mental retardation (Ohira & Aoyama, 1972). Countless dangerous and deadly environmental toxins have impacted the health of many individuals, especially children. These deadly epidemics served as a warning sign; however, the impact of environmental toxins on brain-based disorders, and adverse health effect is often overlooked, underestimated, and ignored (Lanphear, 2015).

Despite the increased knowledge about the hazard of environmental chemicals, testing for Developmental Neurotoxicity (DNT) and reproductive toxicity is rarely done. Manufacturers of commercial chemicals, excluding pesticides, are not required to supply any toxicity data before selling their products under current regulations (Landrigan & Goldman, 2018). Unfortunately, the policies to protect children from environmental toxins is minimal; children are far more vulnerable and sensitive to environmental toxins than adults, yet limited safety measures and policies emplace to prioritize children's safety. Children are simply not “little adults”, children are exceptionally sensitive, and keeping them healthy requires additional and extensive precautions (Landrigan & Goldman, 2018).

Background Information

The National Research Council (NRC, 1993) unveiled the harmful hazards that environmental toxins pose on youth’s health. The council illustrated the fundamental differences amongst children and adults; including the difference in their ability to activate, detoxify and excrete xenobiotic compound. Children also have more rapid metabolic rates than adults, and their metabolic pathways are still immature, lacking proteins that are necessary in the removal of toxins from the body. These physiological differences make adolescents more susceptible to toxins, which presents threats to permanent neurodevelopmental, and behavioral disorders. The National Academy of Sciences reported that children, especially infants in the womb, are profoundly endanger to environmental toxins, due to the difference in their physiological makeup compared to adults.

NRC (1993) also brought concern to the national level, which mandated additional risk assessment to increase the safety of children. The Food Quality Protection Act (1996), requires U.S. Environmental Protection Agency [EPA] to set allowable levels of pesticides, to protect children from chemical residue (Naidenko, 2020). This was a start to protect the development of children. However, as stated by Landrigan and Goldman (2011) the new approach to prevent exposure, which was mandated by the Food Quality Protection Act (1996), have not yet extended beyond pesticides.

Toxic Substances Control Act was passed to measure chemical toxicity through required testing on chemicals in 1976, but the U.S. Congress decided to grandfather into 62,000 chemicals (Landrigan & Goldman, 2011). According to the EPA, these chemicals were allowed to remain in commerce, unless a discovery was made that presented an unreasonable risk to human health or the environment. Toxic Substances Control Act (1976) was an opportunity for the United States to prioritize children's health; however, the U.S. Congress made an egregious decision to neglect the provision of adequate safety measures to protect adolescence. Evidently, great gaps exist with the efforts to protect children, due to limited safety measures, laboratory tests, and regulations on potentially harmful toxins (Landrigan & Goldman, 2011).

Environment of Children

Children are constantly growing, and their developing and immature organs are especially sensitive to toxins. The breathing zone for an adult is typically 4 to 6 ft above ground. However, children are much closer to ground surfaces; and within these lower breathing zones, heavier and harmful chemicals tend to settle and accumulate, posing a significant risk for children (Bearer, 1995). Environmental chemicals are especially dangerous to fetuses during prenatal development. Exposures to environmental toxins such as lead, tobacco smoke, Bisphenol A (BPA) and dichlorodiphenyltrichloroethane (DDT) – a modern synthetic insecticides – during pregnancy have been linked with an increased risk for spontaneous abortion, low birth weight, cognitive/behavioral development complications and preterm birth (Wisborg et al., 2001).

Children’s environments are continuously changing throughout adolescence. At first, as a fetus or newborn, exposure to environmental toxins would most likely be from the mother; through the umbilical cord, placenta, or breast milk. After birth, a child is in a single location for a prolonged period, for example, a crib. Therefore, having baby objects regulated, is especially critical to avoid any prolonged exposure for ensuring that no toxins in the paints, fabrics, or other materials are used. Infants and toddlers are also frequently placed on surfaces, including carpet, flooring, or grass. Perambulatory children are at an increased risk of exposure to chemicals associated with these surfaces, such as formaldehyde and volatile organic chemicals from synthetic carpet and pesticide residues (Bearer, 1995).

Later in life, school aged children can also be at a greater risk depending on their homes, daycares and/or school environments. Risks for environmental hazards are increased, if these locations are near highways with auto emissions and lead, under power lines with electromagnetic fields, or on old industrial sites with benzenea and/or arsenic (Bearer, 1995). Children often do not have a choice on to these decisions; therefore, parents, and caregivers need

to be educated about the importance of avoiding possible environmental risks in their child's daily life.

Types of Toxins

Pesticides

Individuals in our society are at risk for being exposed to chemicals and toxins every day, one of the most likely environmental exposure is pesticides. Organophosphate pesticides are considered the most widely used insecticides in the world, which helps with the production of agriculture (Ross et al., 2013). Naidenko (2020) reported that Food Quality Protection Act (1996) required EPA to set allowable levels for pesticides, and to set an additional tenfold margin of safety "ensure that there is a reasonable certainty that no harm will result to infants and children from aggregate exposure to the pesticide chemical residue" (p. 1518). Naidenko (2020) reviewed 59 pesticides, which were published by the EPA between 2011 and 2019 in a meta-analysis, concluded that the majority of pesticides use did not apply to the Food Quality Protection Act (1996) safety factor, disregarding the opportunity to protect children's health.

Lead

Understanding the toxicity of lead, and lead poising has advanced drastically over the past three decades. Lead poising is known to be the most common environmental disease in the United States. Lead toxicity to the central nervous system in pediatrics has presented adolescence with delayed development, diminished intelligence, and altered behavior; which is especially present in children whose blood lead levels are between 10 and 20 μg/dl. Children usually are exposed to lead through oral ingestion, whereas adults are mostly exposed through inhalation at their workplaces (Landrigan & Todd, 1994). The principal source for high dose exposure to lead for children in the United States was through lead-based paint.

While lead is harmful and causes irreversible negative health impacts were discovered, many individuals in the United States were seriously affected. Lead was not recognized as being dangerous to health, for even the lowest forms of exposure, until the 1970s. Needleman et al. (1990), documented health impact that lead can have on individuals, transforming public health. Unfortunately, lead in paint chips were being digested by children, or being broken down, leaving toxic dusts which are inhalable in households and workplaces. Landrigan and Todd (1994) stated that an estimated 57 million homes in the United States contained lead-based paint. In 1978, all paint companies were required to remove lead from their products; however, lead remained a gas additive in the United States for many more years. In 1972, lead use began to be reduced as gas additive; but unfortunately, was not prohibited until 1996 (Needleman et al., 1990). The discovery of lead toxicity was groundbreaking in science and public health, promoting an increase in safety measures in the United States.

Persistent Organic Pollutants

Persistent organic pollutants (POPs) are carbon containing chemicals that are extremely stable chemically and persist in the environment for long durations of time. POPs can accumulate in high concentrations in fatty tissues, which can be passed from one species to the next through the food chain. Some of the most well-known POPs are Polychlorinated biphenyls—a group of manmade chemicals, DDT, and dioxins. POPs began to be widely used in

industrial production after World War II. Thousands of synthetic chemicals were introduced for commercial use to benefit pest and disease control, crop production, and industry; however, these chemicals had some unforeseen effects on human health and the environment (EPA, n.d.).

Adverse health effects in the human population, have been linked to POPs, including reproductive, developmental, behavioral, neurologic, endocrine, and immunologic complications. Individuals are mainly exposed to POPs through contaminated foods, whereas less common exposure routes include drinking contaminated water. A few populations are at particular risk of POPs exposure, including individuals whose diets include large amounts of fish, shellfish, or wild foods that are high in fat and locally caught (EPA, n.d.).

United States and many other countries signed a United Nations treaty at Stockholm Convention on Persistent Organic Pollutants in 2001, agreed to reduce or eliminate the production, or use, of 12 key POPs, but U.S. residents and wildlife can still be at risk from the POPs that continue to persist in the environment. DDT is likely one of the most well-known and controversial pesticides in history, which was overly used on agricultural crops, particularly cotton, from 1945 to 1972. However, in 1962 the harm of DDT was discovered and brought to a global concern. To date it is unknown of the sufficient tolerable intake, however the use of POPs has diminished drastically since the discovery of the toxicity this chemical poses on human health (Griggs, 2004).

Bisphenol A

Bisphenol A (BPA) is commonly used in polycarbonate plastics, because this chemical is one of the most "physically resistant polymers to environmental stresses" (Moghadam et al., 2012, p. 190). Long term exposure to BPA is identified to cause adverse health effects in both animals and humans. Moghadam et al. (2012) showed a number of health hazards that are attributed to BPA including: estrogenic activity, endocrine disruption, and growth suppression. Fetus, infants and young children up to years of age are revealed to be the most vulnerable population. The industrial chemical BPA is found in many household and food items, including metal cans, sporting and disposable water bottles, and kitchen storage food containers. When BPA based plastic is exposed to high heat, pH value, or pressure, this chemical can seep into the liquid or food, resulting in ingesting of the toxin. For example, water bottles are one of the most commonly used BPA objects, when a water bottle was left in a car in a hot summer day, BPA may leak into the water, contaminating the remaining any liquid. BPA has also been demonstrated to emit from household items, resulting in this toxin being found in dust and inhalable.

One of the most alarming concern was the discovery of baby bottles, which were manufactured with BPA based plastic. When baby bottles temperature raised by formula milk, resulting in a higher risk of BPA emanating into the child's milk. Rising concerns about BPA health hazards, urged the ban BPA in baby specific cups and bottles in 2012 (Moghadam et al., 2012). The U.S. Food and Drug Administration (FDA) also passed a regulation to no longer use BPA-based epoxy resins as coatings in packaging for infant formula, in efforts to protect children. Today, all bottles, cups, plastic and metal food cans in the United States must be labeled "BPA-free" if a food packaging and/or storing object is made without the use of BPA

based plastic, which is regulated by FDA (Moghadam et al., 2012). Therefore, educating the public about buying "BPA-free" products is especially important, particularly for the health of children.

Talc and Asbestos

Both talc and asbestos are naturally occurring minerals that are often found in close proximity to each other in the earth. "In its natural form, some talc contains asbestos, a substance known to cause cancers in and around the lungs when inhaled" (American Cancer Society, 2020, ⁋2). Therefore, sufficient regulations and testing for products that include talc is crucial. Talc is used in many daily cosmetics, such as eye shadow, foundation powder, blush, and lipstick, and other personal care products (U.S. Food and Drug Administration, 2020). However, there is no regulation required by the FDA to test cosmetics for safety before reaching the market. Ingredients can be stated as "talc", "talcum" or "talcum powder".

Wearing talc and/or asbestos products everyday can be harmful to human health, causing possible diseases such as lung, ovarian, and uterine cancers. The linkage between ovarian and uterine cancers was associated with individuals using powders, or condoms with talc, in their genital area, which traveled through their reproductive track. Use of perineal talcum powder was associated with a 13% increase in endometrial cancer risk amongst women, and a 21% increase in risk amongst postmenopausal women (Karageorgi et al., 2010). Johnson and Johnson, Incorporate is subjecting over 19,000 lawsuits relating to their talc baby powder causing cancer, and Missouri Appeal Court suggested that Johnson and Johnson, Incorporate may have been aware of the potential link between talcum powder contaminants and ovarian cancer since the 1960s (Rabin, 2020). Loftus (2020) reported that this lawsuit involved with half of the 22 plaintiffs, died from ovarian cancer. Today, talc is still not listed as a carcinogen, and research is still undergoing regarding the regulation of talc used in the wide range of cosmetic items (American Cancer Society, 2020).

Exposure Routes

Genetics, nutrition, age, and lifestyle are factors can alter an individual's risk to environmentally related illnesses. Exposure to toxins can be through inhalation by breathing, direct contact by touching, and ingestion by swallowing (Bearer, 1995). Exposure routes can determine whether the toxic substance has a serious health effect. For example, breathing or swallowing lead can result in serious neurological disorders, but touching lead is not usually harmful because lead is not absorbed particularly well through skin. Children experience an increased risk of exposure, due the toxins being able to enter the body by various routes including, utero exposure, breast milk exposure, and hand to mouth exposure (Landrigan et al., 2004).

In addition, adolescents have larger skin surface area, and on a pound for pound basis, children drink, eat, and breathe more than adults. Toddlers crawling, also poses a significant risk for children; due to their mouth being close to the ground, and their hands frequently being in their mouth. These findings demonstrate that due to biological, behavioral differences, and body composition, adolescents are at a greater risk to become exposed to harmful environmental toxins. With this current research finding in mind, there are still "great gaps" that exist, creating

limited safety measures, laboratory tests, and regulations on potentially harmful toxins (Landrigan & Goldman, 2011).

Neurological Disorders

The impact of toxins on the developing brain can be detrimental to children resulting in lifelong complications. About 7.6% of U.S. children are estimated to have a parent-reported learning disability, and 13% are estimated to have a mental disorder, including anxiety, autism, conduct disorder, depression, or attention-deficit/hyperactivity disorder (Boyle et al., 2011). The prevalence of developmental disabilities has drastically increased in U.S. children from 1997–1999 to 2006–2008. However, the increase in neurological and behavioral complications can be associated with a variety of different variables, including genetics, which can cause addressing and identification of the exact source to be complicated. Intellectual deficits in children most often thought to result mostly from poor parenting or genes (Lanphear, 2015). Today, biomarkers can be used to measure the internal dose of many environmental chemicals in human tissues linking these exposures with a certain disability or disease (Sexton et al., 2004).

Interventions

Educating Pediatricians, Parents, Caregivers, and the Public

Evidence is mounting that environmental exposures are contributing to the drastic increase in disease amongst children. Yet in 2003, few pediatricians are trained to diagnose, treat, or prevent disease of environmental origin. With 125 medical schools where analyzed, those curricula are listed in the Curriculum Directory of the Association of American Medical Colleges, only two reported a required course in environmental medicine. That was less than 1% of medical schools who prioritize in the education of possible environmental risks, and diseases associated. Proper education regarding environmental toxins is advancing slowly. Future and current healthcare workers are now prioritizing in the importance of environmental toxins, and the possible health effects associated (Landrigan et al., 2007). Prevention is the most important intervention in the field of toxicity. Parents, caregivers, children, teachers, community leaders, and policy makers need to be educated about the unique vulnerability of children to environmental pollution, which can be done through the United States federal and public agencies, such as the FDA and CDC. These government agencies can use their websites to advocate for children's health, by posting up-to-date information regarding the types of common and deadly environmental toxins, and how to take proper safety measures.

Regulations

The optimal strategy to prevent risks of developmental brain-based disorders due to environmental toxins is to first- identify and restrict, or prohibit the use of potential harmful chemicals, before they are advertised or allowed into the environment. Unfortunately, as of now, industries can market a product, until otherwise shown to be toxic in both human. Regulatory framework needs to be revised, requiring all U.S. industries to provide evidence that chemicals are not considered to be toxic to human health and to the environmental, before these products are marketed and allowed for manufacture use (Lanphear, 2015).

Conclusion

Environmental toxins can have a lifelong impact on brain development and behavioral functions. Children are especially vulnerable, and are most likely to experience irreversible damage, simply due to their physical and biological differences compared to adults. Children are closer to the ground and are often in one area for a prolonged period, presenting a greater risk to encounter harmful chemicals in their environment (Bearer, 1995). Adolescents also have many biological differences, including the distinction in their ability to activate, detoxify and excrete xenobiotic compounds (NRC, 1993). Therefore, regulation implementation by the U.S. Government is crucial to protect children, and to educate parents and caregivers about the risk and hazards of environmental toxins.

References

American Cancer Society. (2020, February 4) Talcum powder and cancer. https://www.cancer.org/cancer/cancer-causes/talcum-powder-and-cancer.html

Bearer, C. F. (1995). How are children different from adults? Environmental Health Perspectives, 103(Suppl 6), 7-12. doi:10.1289/ehp.95103s67

Boyle, C. A., Boulet, S., Schieve, L. A., Cohen, R. A., Blumberg, S. J., Yeargin-Allsopp, M., . . . Kogan, M. D. (2011). Trends in the prevalence of developmental disabilities in US children, 1997-2008. Pediatrics, 127(6), 1034-1042. doi:10.1542/peds.2010-2989

Food Quality Protection Act of 1996, Pub. L. No. 104-170, 110 Stat. 1518 (1996). https://www.congress.gov/104/plaws/publ170/PLAW-104publ170.pdf

Grigg, J. (2004). Environmental toxins; their impact on children's health. Archives of Disease in Childhood, 89(3), 244-250. doi:10.1136/adc.2002.022202

Harada, M. (1995). Minamata Disease: Methylmercury poisoning in Japan caused by environmental pollution. Critical Reviews in Toxicology, 25(1), 1-24. doi:10.3109/10408449509089885

Karageorgi, S., Gates, M. A., Hankinson, S. E., & De Vivo, I. (2010). Perineal use of talcum powder and endometrial cancer risk. American Association for Cancer Research, 19(5), 1269–1275. https://doi.org/10.1158/1055-9965.EPI-09-1221

Landrigan, P. J., & Goldman, L. R. (2018. October 2). A bad move that could end up exposing kids to chemicals. The New York Times. https://www.nytimes.com/2018/10/02/opinion/chemicals-epa-children-health.html

Landrigan, P. J., & Goldman, L. R. (2011). Children's vulnerability to toxic chemicals: A challenge and opportunity to strengthen health and environmental policy. Health Affairs, 30(5), 842-850. doi:10.1377/hlthaff.2011.0151

Landrigan, P. J., Woolf, A. D., Gitterman, B., Lanphear, B., Forman, J., Karr, C., . . . Crain, E. (2007). The ambulatory pediatric association fellowship in pediatric environmental health: A 5-year assessment. Environmental Health Perspectives, 115(10), 1383-1387. doi:10.1289/ehp.10015

Landrigan, P. J., Kimmel, C. A., Correa, A., & Eskenazi, B. (2004). Children's health and the environment: Public health issues and challenges for risk assessment. Environmental Health Perspectives, 112(2), 257-265. doi:10.1289/ehp.6115

Landrigan, P. J., & Todd, A. C. (1994). Lead poisoning. Western Journal of Medicine, 161(2), 153–159. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1022528/

Lanphear, P. B., (2015). The impact of toxins on the developing brain. Annual Review of Public Health, 36(1), 211-230. doi:10.1146/annurev-publhealth-031912-114413

Loftus, P. (2020, June 23). Missouri court cuts talc-powder verdict against J&J to $2.1 billion. The Wall Street Journal. https://www.wsj.com/articles/missouri-court-cuts-talc-powder-verdict-against-j-j-11592935876

Moghadam, Z. A., Mirlohi, M., Pourzamani, H., & Malekpour, A. (2012). Bisphenol A in "BPA free" baby feeding bottles. Journal of Research in Medical Sciences, 17(11), 1089–1091. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3702095/

Naidenko, O. V., (2020). Application of the food quality protection act children's health safety factor in the U.S. EPA pesticide risk assessments, Environmental Health, 19, Article 16. https://doi.org/10.1186/s12940-020-0571-6

National Research Council (1993). Pesticides in the diets of infants and children. Washington, DC: The National Academies Press. https://doi.org/10.17226/2126

Needleman, H. L., Schell, A., Bellinger, D., Leviton, A., & Allred, E. N. (1990). The long-term effects of exposure to low doses of lead in childhood – An 11-Year Follow-up Report. New England Journal of Medicine, 322(2), 83-88. doi:10.1056/nejm199001113220203

Ohira, M., & Aoyama, H. (1972). 森永砒素ミルク中毒に関する疫学調査: 瀬野地区における広大 [Epidemiological studies on the Morinaga powdered milk poisoning incident]. Nippon Eiseigaku Zasshi [Japanese Journal of Hygiene], 27(6), 500-531. doi:10.1265/jjh.27.500

Rabin, R. C. (2020, June 23). Women with cancer awarded billions in baby powder suit. New York Times. https://www.nytimes.com/2020/06/23/health/baby-powder-cancer.html?searchResultPosition=2

Ross, S. M., McManus, I. C., Harrison, V., & Mason, O. (2013). Neurobehavioral problems following low-level exposure to organophosphate pesticides: A systematic and meta-analytic review. Critical Reviews in Toxicology, 43(1), 21-44. doi: 10.3109/10408444.2012.738645

Sexton, K., Needham, L. L., & Pirkle, J. L. (2004). Human biomonitoring of environmental chemicals: Measuring chemicals in human tissues is the "gold standard" for assessing people's exposure to pollution. American Scientist, 92(1), 38-45. http://www.jstor.org/stable/27858331

U.S. Environmental Protection Agency [EPA]. (n.d.). Persistent organic pollutants: A global issue, a global response. Retrieved December 26, 2020 from https://www.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response

U.S. Food and Drug Administration [FDA] (2020. August 18). Talc. https://www.fda.gov/cosmetics/cosmetic-ingredients/talc

Wisborg, K., Kesmodel, U., Henriksen, T. B., Olsen, S. F., & Secher, N. J. (2001). Exposure to tobacco smoke in utero and the risk of stillbirth and death in the first year of life. America Journal of Epidemiology, 154(4), 322-327. https://doi.org/10.1093/aje/154.4.322