# The Negative Effects of Neurotoxins on Mental and Physical Health: A Systematic Review

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## ABSTRACT

Neurotoxins are health-hazardous toxins that exist in our environment and impact the health of humans. Neurotoxins are in our food, water, and environment, with exposure causing mild to severe health effects. This paper reviews the negative effects of neurotoxins on human mental and physical health. The discussion centers around the types of neurotoxins that are commonly found in the domestic and outside environment including Volatile Organic Compounds (VOCs), formaldehyde, heavy metals, phthalates, glyphosate, pesticides, and herbicides. This review aims to inform individuals of what may be contributing to their quality of life and health.

## Introduction

The mental and physical health conditions that impact our society seem to have been getting worse as time passes. The elevated health concerns correlate to neurotoxin exposure, including glyphosate, phthalates, PFAs, PFOAs, and heavy metals. Neurotoxins have a wide range of adverse effects on mental and physical health in our food, water, air, and environment.

Neurotoxic health effects can range from severe to long-term, such as the condition of fibromyalgia (Bilić et al., 2014). These toxins are detrimental, with an incredibly adverse impact. Neurotoxins plague our environment and prove a clear correlation between the onset and or worsening of mental (Grandjean et al., 2006) and physical health concerns in humans.

Neurotoxins, such as glyphosate, are manufactured, and naturally occurring matter, such as heavy metals, including copper and aluminum (Ref). The toxins exist in our environment and disrupt brain and body functions. Our air alone contains heavy metals (Melaku, 2008) and volatile organic compounds (VOCs) (Khan et al., 2000) as well as formaldehyde (Herrero et al., 2022)., particulate matter (PM), and ultrafine particulate matter (UFPM) (Costa et al., 2017). Exposure to air neurotoxicity is challenging to avoid, especially with emissions from cars, factories, and household products like perfumes and house cleaners (Kim et al., 2001). According to Neurotoxicity of Traffic-Related Air Pollution, vehicle pollution significantly contributes to the growing concern for air quality, with 40 known toxins in diesel exhaust alone (Costa et al., 2017). Our air is contaminated. There are negative impacts from toxic emissions. Toxic pollutants in the air are linked to adverse health effects on the brain and the body, especially the respiratory system (George et al., 2000).

Beyond aerosols, emissions, and other sprays that pollute the air with neurotoxins, many household items emit VOCs (Kumari et al., 2019) and formaldehyde (Herrero. 2022. These toxins are in household items, including furniture, carpets, wall paint, and plastic shower curtains. Household items such as furniture are often treated with formaldehyde, made with PVC or polyester, and other chemicals to create and manufacture the product (Herrero. 2022).

Along with air, water is also deeply contaminated with neurotoxins, including heavy metals (Lesmana et al., 2009). Pharmaceuticals also contaminate our drinking water, damaging our health (Sun et al., 2014). A

study in China, Occurrences of Pharmaceuticals in Drinking Water Sources of Major River Watershed to Analyze the Number of Pharmaceuticals Detected in Drinking Water, concluded that 70 out of 135 water samples were contaminated with pharmaceuticals (Sun et al., 2014).

Food is a complicated matter when it comes to neurotoxins. What we ingest is often coated in herbicides, and pesticides (Kumarai et al., 2019), genetically modified (Parondini et al., 2008), injected or exposed to chemicals (Al-Amri et al., 2021), and phthalates (Wang, 2021). Pesticides alone are a considerable danger to humans, leading to developmental issues and problems for the fetus during gestation (Hagen et al., 2013).

Food is one of the most challenging areas of life to avoid neurotoxin exposure due to its contamination across crops and ingredients from the heavy use of pesticides (Hagen et al., 2013). Individuals face severe threats to their well-being and health, from neurotoxicity ranging from packaging to food. Food exposed to aluminum from cooking or packaging raises the risk of heavy metal leaching into the food (Mohammad et al., 2011), and storage in plastics increases the risk of leaching phthalates and other toxins into the food (Wang, 2021). That means if someone buys organic foods, they can still carry neurotoxicity depending on the type of processing and packaging they went through.

Household items carry a significant risk of exposure to neurotoxins. Specific cookware coated in nonstick, such as Teflon, contains PFAs and or PFOAs, which are forever chemicals, releasing thousands of microplastics when the surface scrapes during normal cooking wear and tear (Luo et al., 2022). Scrapes on the pans coated in nonstick coatings like Teflon can free 2,300,000 microplastics (Lou et al., 2022). Clothing, tables, clothes, and other materials, such as bed sheets, can hold pesticides, formaldehyde, and other chemicals that leach into the skin during exposure (Herrero. 2022). Cosmetics, foods, pharmaceuticals, cleaners, and other skin and health care products may contain parabens (Kirchhof et al., 2013), phthalates, PFAS, PFOS (Beans et al., 2021), and other harmful ingredients that absorb into the skin as well, carrying neurotoxic impacts. The list goes on, including medications treated with titanium dioxide to turn the color white (Baranowska-Wójci et al., 2020).

Unfortunately, we are surrounded by neurotoxicity wherever we go, from the air we breathe to the food we eat. Neurotoxins are inescapable, and the risks are high. Understanding the aversive effects of neurotoxins and their impact on human health will help individuals make more informed decisions about what they expose themselves to in their environment. Food, for example, is contaminated with pesticides, herbicides (Hagen et al., 2013), genetically modified ingredients (Pirondini et al., 2008), and other neurotoxic ingredients. There is a link between pesticides and severe health problems, including developmental disorders, academic disorders, and more (Hagen et al., 2013).

Understanding the neurotoxicity of the individual's environment allows them to make an informed decision on the diet they eat and feed their family. Changes may include going organic or growing their food. Across all the studies reviewed, it is clear that the health impact of neurotoxins is significant and dangerous. All the studies that have been reviewed share the same theme. The common conclusion is that neurotoxins negatively impact the health of humans, whether that be mildly or as severe as cancer and death.

This review aims to discuss the harmful health effects correlated to neurotoxin exposure and open the conversation to what is lurking in our homes and the world. This review will also focus on how neurotoxins are entered into the human body and alternatives or ways to reduce exposure to them. The review will go in-depth on the correlation between mental and physical health concerns and neurotoxin exposure and how it changes the structure and inner workings of the brain.

## Neurotoxins in the Environment

Out of all these influences, the growing desire for convenience has created an overbearing rise in neurotoxins in our environment. Humans want food quickly and in large quantities, leading to genetically modified ingredients so that foods would be larger with more fruiting (Cavacos et al., 2016). The desire to have inexpensive

ways to package and process foods and items meant the implementation of tons of microplastics (Wang, 2021). On top of that, the urge to quickly grow farm animals for food led to injecting meats with steroids, antibiotics, and other toxins (Al-Amri et al., 2021). Society wanted an easy way to protect crops massively, which opened the door to spraying pesticides and herbicides on our food (Ruah, 2016), making it easier to eat authentic, uncontaminated food if it is entirely organic.

## Ways of Entry into the Human Body

Exposure to neurotoxins occurs through many different outlets. Neurotoxins can be leached through the skin, ingested, or inhaled. According to Alternative to Artificial Preservatives: Systematic Reviews in Pharmacy, leaching through the skin can occur by touching an affected surface that contains a neurotoxin, such as a table sprayed with bleach or chemicals (Kumari, 2019). It can also transpire when someone touches surfaces that are contaminated. For example, our skin can absorb formaldehyde from wearing contaminated clothing (Herrero. 2022). Fabrics and materials like sheets, blankets, and clothing contaminated with formaldehyde and dyes also leach into the skin (Herrero et al., 2022). The literature, Alternative to Artificial Preservatives: Systematic Reviews in Pharmacy, further discusses the many neurotoxins in our environment, including parabens, formaldehyde, preservatives, and sulfates (Kumari et al., 2019). These are only some of the few neurotoxic chemicals in our everyday lives that can leach into our skin and affect us.

Kumari and others (2019) stated that preservatives extend shelf life so that food lasts longer. Besides foods, they are in many cosmetics and pharmaceutical medications, including vaccines. While this may sound good, it is hazardous, especially when the preservative is a chemical. Preservative chemicals can enter through ingesting food, touching contaminated surfaces and clothing, and inhaling if it is in the air (Kumari et al., 2019). The literature lists “Benzoates, sorbates, nitrites, and nitrates of sodium or potassium, sulfites, glutamates, and glycerides” as some of the chemical preservatives found in our foods, cosmetics, care products, and other household items (Kumari et al., 2019).

The second way of entry for neurotoxins is through inhalation. Khan and others (2000) studied the removal of volatile organic compounds from polluted Air and discussed the inhalation effects of VOCs, an air pollutant. VOCs or volatile organic compounds exist in the air, from everyday household items to other chemical gas emissions, including household products, thinners, cleaners, and other arousal products that produce emissions. They are known to damage the health of life forms and the environment. Systems, tanks, and vessels emit pollutants such as VOCs (Khan et al., 2000).

A third study reinforced the information Kumari and others (2019) discussed, Alternative to Artificial Preservatives: Systematic Reviews in Pharmacy. Research Review: Environmental Exposures, Neurodevelopment, and Child Mental Health discussed the dangers of preservatives once ingested through foods (Rauh, 2016). The article mentioned that about a dozen neurotoxins currently have neurodevelopmental effects on adolescents, but thousands of other neurotoxins still need to be tested (Rauh, 2016). The fact that there are thousands of neurotoxins believed to have correlations to health effects is alarming and a serious matter. We as a society are dealing with uncertainty about the safety of our foods and our environment.

Picking toxin-free food is more complicated than it seems. Crops and produce are sprayed with pesticides, herbicides, and insecticides (Kumarai et al., 2019). With the high volume of spraying of crops, we are ingesting contaminated foods. The study further discussed how the brain is very vulnerable to neurotoxins and that lead and pesticides are two neurotoxins known to have done much damage (Ruah, 2016). Knowing that

pesticides are one of the two neurotoxins directly linked to severe health problems (Ruah, 2016) should raise much awareness of what is in an individual's food and its impact on their health.

## Reducing Exposure

Luckily, there are ways to reduce exposure and eliminate existing neurotoxins from the environment. Some processes take longer than others, like detoxing one's body from heavy metals, while some forms of reduction may be as simple as replacing household items. There are a few options to reduce exposure to neurotoxins found in the air. Reduction is more feasible in the domestic environment where the individual has control over what they implement, and it is much more difficult to nearly impossible to change the exposure outdoors. For example, avoiding places that produce emissions, such as heavily trafficked or industrial areas, may be challenging in some cases.

The study Removal of Volatile Organic Compounds from Polluted Air discusses how someone can destroy Vocs by using a thermal oxidation system (Khan et al., 2000). The system uses high heat that destroys "about 95% to 99%" of the VOCs in the treated area (Khan et al., 2000). The literature further suggests other removal forms, such as using a reverse flow reactor, catalytic oxidation, bio-filtration, absorption, or condensation (Khan et al., 2000). The type of VOC removal would depend on what one can afford and what would best fit one's home or environment. To find out how much contamination is in the air and how much was removed by a system or technique, an air quality meter that measures VOCs and other neurotoxins can aid in awareness of pollutants in the air (Turkyener et al., 2021).

Reduction of neurotoxicity in drinking water comes with a necessary lifestyle modification. Avoiding water from plastic bottles is essential due to the number of phthalates or microplastics that are leached into the water as well as heavy metals (Wang, 2021). The water contamination affects the food we gather from the ocean. Many fish now have heavy metal contents such as mercury due to exposure to heavy metals, which we can ingest should we eat contaminated fish (Dallinger et al., 1987).

In drinking water alone, wells and water plants have neurotoxins, including the heavy metals chromium, lead, copper, cadmium, nickel, zinc, and more. (Lesmana et al., 2009). A whole house reverse osmosis water system would be encouraged for the entire water line in the home, not just for the drinking water (Bakalár et al., 2009). According to Heavy Metal Removal Using Reverse Osmosis, implementing a reverse osmosis system for water systems reduces exposure to neurotoxins (Bakalár et al., 2009). In reverse osmosis, water pushes through cylinder filters layered with permeable membranes that help filter out different-sized particles (Water et al., 2016). The literature specifically targeted the removal of copper, zinc, and nickel from waterways, and their results concluded a significant decrease in the heavy metals when the reverse osmosis system was implicated (Bakalár et al., 2009).

Removing pesticides can help reduce neurotoxin exposure by having an organic diet (Benbrook, 2021). According to Neurotoxicity of Pesticides, pesticides are sprayed on crops and are directly correlated to adverse health effects (Richardson et al., 2019). Pesticides, herbicides, and insecticides are sprayed on crops and produced to eliminate bugs and pests. However, they have detrimental health effects, and precautions are needed to avoid them (Richardson et al., 2019). The article further explains the various types of pesticides and their effect on human health, including herbicides, DDT, and Dieldrin (Richardson et al., 2019). Exposure to these neurotoxins can be reduced by changing to an organic diet and purchasing non-GMO foods. Growing a garden is another excellent way to avoid these toxins as long as the gardener does not spray any toxins on the plants and chooses organic seedlings and plants (Benbrook, 2021)

## Brain Structure Changes

Neurotoxins change the structure and internal workings of the brain (Sapolsky, 2000). The neural changes are a significant issue for every individual. However, it is perilous for adolescents due to their developing brains (Rauh et al., 2016). The literature, The Possibility of Neurotoxicity in the Hippocampus in Major Depression: A Primer on Neuron Death, discusses how neurotoxins are responsible for shrinking and damaging the hippocampus (Sapolsky, 2000). Over time, the more neurotoxin exposure an individual receives, the more it builds up and disrupts the chemical balance inside the brain. Neurotoxicity in the brain can disrupt and change how neurons communicate, igniting mental conditions and other aversive changes (Sapolskly, 2000). The literature discusses how these toxins affect neural cells and cause cell death. Neural and cell death correlate with mental conditions such as post-traumatic stress disorder, major depression, and other mental health disorders associated with a smaller hippocampus (Sapolskly, 2000).

On another note, neurotoxicity is responsible for dysregulation within the brain, which is a cause of damage that changes the capacity of the brain to grow and develop (Costas-Ferreira et al., 2022). Toxic Effects of Glyphosate on the Nervous System: A Systematic Review concludes that a specific neurotoxin found in food, glyphosate, is responsible for severe changes in the brain, including dysregulation in the neural pathways, and affects neural growth, differentiation, myelination, and migration. (Costas-Ferreira, et al. 2022) Glyphosate is one of the many neurotoxins found in our food. Glyphosate alone is in many food products that are on grocery store shelves today because it is a pesticide and is sprayed on crops and produce (Cox et al., 1998)

The impact neurotoxins have on the brain is critical. They disrupt communications with other neurons and lead to cell death (Sapolsky et al., 2000). In addition to glyphosate, other pesticides also carry these harmful effects, deteriorating the brain and leading many individuals on a neurodegenerative path. Another literature, Guam ALS/parkinsonism-dementia: A Long-Latency Neurotoxic Disorder Caused by “Slow Toxin(s)” in Food? (Spencer, 1987), shares a similar conclusion to The Study Toxic Effects of Glyphosate on the Nervous System: A Systematic Review concludes that a specific neurotoxin found in food, glyphosate, is highly harmful (Costas-Ferreira et al., 2022).

## Adolescent Neurodevelopment Correlation

Due to their developing brains, children, in particular, are highly vulnerable to the effects of neurotoxins (Rauh et al., 2016). According to Research Review: Environmental Exposures, Neurodevelopment, and Child Mental Health - New Paradigms for the Study of Brain and Behavioral Effects, children are the population that is most vulnerable to neurotoxins, which have adverse effects because of their developing brains (Rauh et al., 2016). The environment in which the pregnant mother is in has an impact on the fetus during gestation. The developing brain is critically vulnerable to chemical changes (Ahmad et al., 2020). The children's brains are in the process of creating new connections, forming and growing.

The literature, Mental Retardation and Developmental Disabilities (MRDD) are Influenced by Environmental Neurotoxic Insults, discusses the increase in environmental pollutants, which raises the number of individuals developing (MRDD) and affects fetuses during the gestation period, leading to illness. Exposure to these chemicals raises the vulnerability of children, causing developmental disorders (Shroeder, 2000). As discussed, pesticide exposure directly impacts human health. Children's exposure to pesticides, especially in large quantities, increases their risk of developing unwanted physical and mental health concerns (Shroeder, 2000). The literature explained the correlation between the frequent use of ‘pesticides’ and the exposure to neurotoxins of pregnant mothers with an academic decline in their children and developmental disabilities (Hagen et al., 2013). The study, Developmental Neurotoxicity of Industrial Chemicals, analyzes the correlation between developmental disorders, including ADHD, cerebral palsy, mental retardation, autism, and neurotoxic industrial chemicals in the environment. Exposure to toxins as young infancy harms the individual brain (Grandjean et al., 2006). The chemicals known to have adverse and dangerous effects on the child's brain are lead, methylmercury, polychlorinated biphenyls [PCBs], arsenic, and toluene (Grandjean et al., 2006).

## Neurodegenerative Correlation

The effect neurotoxins have on mental health is significant, correlating to numerous mental health concerns and disorders. The literature, Guam ALS/parkinsonism-dementia: A Long-Latency Neurotoxic Disorder Caused by "Slow Toxin(s)" in Food" discusses the correlation between neurotoxic pesticides and degenerative diseases. These diseases include dementia (Spencer, 1987). Prevention for degenerative diseases needs to start as young as possible. As mentioned in a previous article, The Possibility of Neurotoxicity in the Hippocampus in Major Depression: A Primer on Neuron Death, neurotoxins are responsible for cell death (Sapolsky, 2000). The degradation over time can cause degenerative diseases such as Alzheimer's and dementia (Spencer, 1987).

The literature, Guam ALS/parkinsonism-dementia: A Long-Latency Neurotoxic Disorder Caused by "Slow Toxin(s)" in Food, further discussed the slow degression of the brain over time. The more the brain digresses from pesticide neurotoxicity, the more symptoms of early degenerative diseases (Spencer, 1987). Unfortunately, the dangers of neurotoxins go as far as causing deregulation in the brain, disrupting the interior workings of the brain. According to The Dynamics of Autism Spectrum Disorders, there is a correlation between autism and neurotoxin exposure (Quaak et al., 2013). The study states an increase in diagnosis: "From 2007 to 2011–2012, the incidence of ASD rose from 1.16% to 2.00% in the United States of America" (Quaak et al., 2013). Like Developmental Neurotoxicity of Industrial Chemicals (Grandjean, 2006), the literature The Dynamics of Autism Spectrum Disorders describes a correlation between autism and neurotoxin exposure that shares the same warnings against PCBs (Quaak et al., 2013). PCBs, in particular, seem to have a horrible reputation for the health of individuals. The study states that polychlorinated biphenyls (PCBs) are one of the culprits of adverse effects on brain development (Quaak et al., 2013).

## Correlation to Physical Health

The brain is the control system for the body. If that becomes damaged, unfortunate consequences can be mild to life-threatening. Neurotoxin exposure leads to health complications. The literature, Public Health Vulnerability Due to the Exposure of Dissolved Metal(Oid)s in Tap Water from a Mega City (Dhaka, Bangladesh), examined the heavy metals and neurotoxins in the tap water of Dhaka City and the detrimental health effects it had on its citizens (Soltani-Gerdefaramarzi, 2021). As discussed previously, heavy metals correlate with adverse health reactions (Bakalár et al., 2009). Many drinking water sources are contaminated with heavy metals (Bakalár et al., 2009), and heavy metals also exist in the air (Melaku, 2008). Some physical conditions associated with heavy metal toxicity from drinking water include CAD, neurotoxicity, GI Inflammation, blood diseases, and aches and pains (Soltani-Gerdefaramarzi, 2021).

In regards to foods, there is a correlation between phthalates and health concerns. According to Phthalates and Their Impacts on Human Health, phthalates exist in many plastic products, including our food (Wang, 2021). There are countless health concerns that neurotoxicity is linked to, from developmental disorders (Shroeder, 2000) to respiratory conditions (George et al., 2000) and other physical health problems. Phthalates, specifically, are linked to numerous health disorders, including "obesity, allergies, asthma, diabetes, and insulin resistance (Wang, 2021). The article also explains the slow deterioration of the body and metabolic effects depending on the type of phthalate exposure the individual receives. (Wang, 2021).

While all health concerns are pressing, fibromyalgia, one of the top three muscular-skeletal conditions that have become commonly diagnosed (Sarzi-Puttini et al., 2020), has an onset correlation to neurotoxicity. The study, Neurotoxin-induced fibromyalgia or fibromyalgia after ciguatera (tilapia fish) poisoning? It brings

to light how a specific neurotoxin found in fish, ciguatera, has a correlation to fibromyalgia and is believed to be the onset of the condition (Bilić et al., 2014). There is a direct correlation between Ciguatera and fibromyalgia; however, many other neurotoxins also correlate. There is also suspicion that other neurotoxic bacteria can impact the onset of this condition (Bilić et al., 2014).

## Conclusion

The literature reviewed has contributed essential data and information regarding neurotoxins' dangers and adverse effects. The studies proved direct health impacts and correlations to mental and physical health concerns while pointing out specific contributing neurotoxins and discussing their effects on the human body. Neurotoxins plague our environment and negatively impact the physical and mental health of humans. Weaknesses throughout the literature include failure to provide in-depth studies on pesticide exposure, as explained by the Neurotoxicity of pesticides. There is a lack of longitudinal studies that could provide more helpful data and understanding of the long-term effects of these toxins. As a strength, the literature reviewed shows strong evidence of a correlation between neurotoxins and adverse health effects, especially in adolescents regarding neurodevelopment.

More research with longitudinal studies would be beneficial to see exposure's impact over the years. Research in the future should also include studies on the removal of neurotoxins from the individual's environment and the impact it has on their health over time. We need to see more data on high-risk individuals (immunocompromised, adolescents, elderly) and low-risk individuals (healthy, young adults) to see if there is a difference in resilience and vulnerability to the toxins.

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