Nutritional epigenetics

The link between diet, autism, and ADHD

- There is an increase in the number of children with neurodevelopmental disorders such as autism and ADHD, coinciding with an increase in ultra-processed food (UPF) intake.
- Dr Renee J Dufault is an independent researcher in the USA whose work focuses on how diet impacts gene expression.
- Dufault identified genes that may be affected by the composition of UPFs and harnessed this knowledge for health education programmes to encourage healthy eating in parents.

It is well known that diet type and quality are tied to health – but can nutrition also impact our genetic code? Nutritional epigenetics describes how food and diet impact gene expression, the process by which information encoded in a gene is turned into a practical function.

Ultra-processed foods, or UPFs, have been making the headlines recently due to their negative impact on human health if eaten in large amounts. There are a number of ways in which these foods influence health, for example, through their high salt, sugar, and fat content. There may be contaminants within these food ingredients that act at a deeper level within the body.

Autism and attention deficit/hyperactivity disorder (ADHD) are neurodevelopmental disorders that affect the brain. They can result in a variety of behaviour changes, primarily impacting social and communication skills. The World Health Organization estimates that around 1 in 100 children has autism, which is often not diagnosed until later in life. As consumption of UPFs increases in the USA, so does the prevalence of autism and ADHD, suggesting there could be a potential link between the two.

Nutritional epigenetics describes how food and diet can impact gene expression.

Independent researcher Dr Renee J Dufault is specifically interested in how two genes, called metallothionein (MT) and paraoxonase-1 (PON1), are involved in autism and ADHD. While working as a researcher at the US Food and Drug Administration (FDA), Dufault discovered compounds within UPFs that may impact the expression of MT and PON1. For example, she found high fructose corn syrup consumption may lead to mineral imbalances such as zinc loss, and dietary lead exposures could lead to calcium loss. She concluded that exposure to heavy metal content, or some food ingredients, creates deficits in certain nutrient levels that directly or indirectly impact gene expression. She suggests that a prenatal diet high in UPFs is a primary epigenetic factor in the development of autism/ADHD through the suppression of MT and PON1 genes. Dufault was also the first to develop a nutritional epigenetics model to explain how these gene–environment interactions create conditions for the development of autism and ADHD.

Gene expression of MT and PON1

Contaminants in food such as mercury, a heavy metal, can alter the adaptability

of neurons. Neurons that are less flexible can play a factor in the development of neurodevelopmental conditions. On the other hand, including more foods high in nutrients such as omega-3 fatty acids, zinc, and selenium is associated with better neuronal function.

As dietary zinc is also essential for maintaining the metabolic processes involved in eliminating heavy metals from the body, there is an additional benefit to maintaining a nutritionally balanced diet. This metal elimination process occurs with input from a protein called metallothionein, which is encoded by the MT gene.

Dufault highlights that patterns of gene expression also vary geographically due to dietary differences among cultures. For example, gene variants of PON1 are associated with autism the US but not in Italy. Americans consume vast amounts of high fructose corn syrup that are found in UPFs.

She suggests that inadequate intake of minerals such as calcium and magnesium may cause a reduction in PON1 gene expression. This can lead to higher levels of a compound called homocysteine, which is associated with oxidative stress and epigenetic changes that could be transferred between generations, affecting neurodevelopment. PON1 is also important for the excretion of pesticide residues, which Dufault identified at high levels in UPFs. In a recent review of the United States special education data, Dufault found a three-fold increase in autism prevalence and a four-fold increase in development delay among students enrolled in public schools between 2006 and 2021.

Dufault hopes that educating parents about diet quality will reduce their intake of UPFs and minimise the risk of children developing neurodevelopmental conditions.

These increases occurred even though student enrolment numbers remained essentially flat.

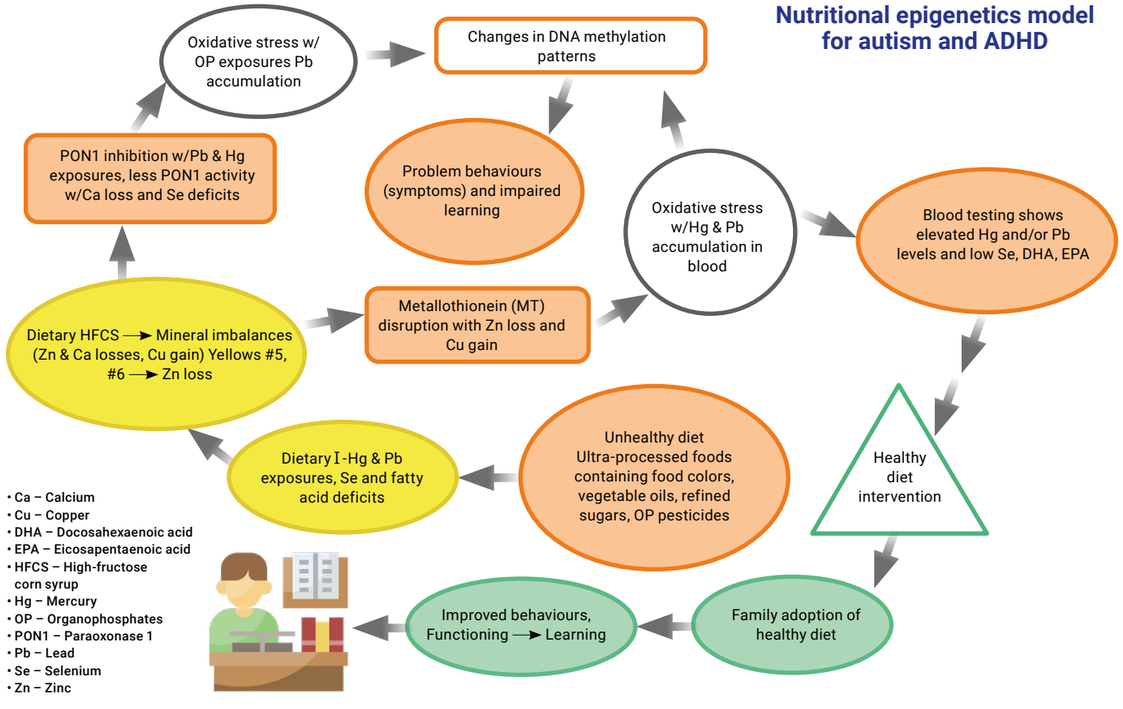
Previous research has shown a link between intake of UPFs and adverse child neurodevelopment. As well as impacting gene expression, intake of UPFs has also been linked to dysbiosis of the gut microbiome (when the ecosystem of bacteria found in the large intestine is out of balance) frequently seen in children with autism and ADHD. It is hard to establish cause and effect, as children with neurodevelopmental needs often have a restricted diet pattern, which may also contribute to suboptimal gut health. However, reducing the intake of UPFs brings many benefits, particularly in lowering the intake of pesticides and heavy metals, as highlighted by Dufault.

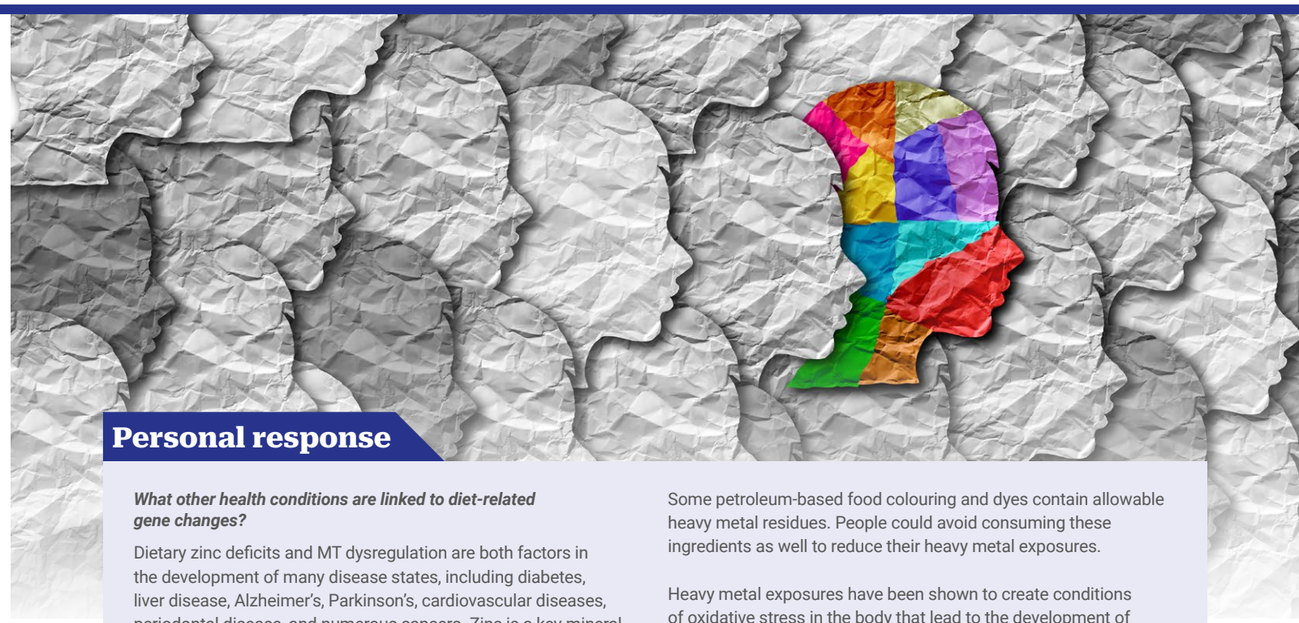
Health education programmes

Dufault has used her research findings to inform health education intervention programmes focusing on nutritional epigenetics. These programmes have successfully been utilised in clinical trials where participants have been encouraged to reduce their intake of UPFs and replace these with fresher, whole unprocessed foods.

One study undertaken by Dufault involved a six-week course about nutritional epigenetics to help parents reduce their intake of UPFs. This is a novel approach to dietary education sessions, as they rarely include information about the links between nutrition and gene expression. In learning how food impacts how genes behave, parents were more motivated to make dietary changes and showed improvements in overall diet quality, characterised by a decrease in UPFs.

In another nutrition study led by Dufault, outcomes showed that participants who adopted a healthier diet had a decrease in blood mercury and glucose levels. Dufault hopes that educating parents about diet quality will reduce their intake of UPFs and minimise the risk of children developing neurodevelopmental conditions. Providing parents with the necessary tools and knowledge enables them to become empowered about nutritional choices.





Personal response

What other health conditions are linked to diet-related gene changes?

Dietary zinc deficits and MT dysregulation are both factors in the development of many disease states, including diabetes, liver disease, Alzheimer's, Parkinson's, cardiovascular diseases, periodontal disease, and numerous cancers. Zinc is a key mineral for maintaining health as it is required to build several epigenetic enzymes that maintain DNA and immune functions.

What is the one thing that people could do to reduce intake of UPFs?

People can read UPF ingredient labels and avoid consuming products that contain ingredients known to cause zinc or calcium losses in humans. Some specific food ingredients linked to zinc loss and/or metabolic imbalance are high fructose corn syrup, yellow #6 (tartrazine), yellow #5, sodium benzoate, and glucose. Some petroleum-based food colouring and dyes contain allowable heavy metal residues. People could avoid consuming these ingredients as well to reduce their heavy metal exposures.

Heavy metal exposures have been shown to create conditions of oxidative stress in the body that lead to the development of disease. Because bleached flour may contain mercury, lead, and pesticide residues, people could also avoid consuming products made from bleached flour.

What research project would you like to work on next?

I enjoy conducting education intervention studies that focus on dietary factors involved in nutritional epigenetics modelling and would welcome any opportunity to collaborate with researchers with similar interests.

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Bio

Dr Renee J Dufault, a former Public Health Service officer, retired early from the Food and Drug Administration to publish her findings of mercury in high fructose corn syrup. As a whistleblower, she could not find employment in academia, so she founded a non-profit research institute where she works as a volunteer. Dufault is considered a leader in the field of nutritional epigenetics with 780 citations according to Google Scholar.

Further reading

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