FASD-CAN
Fetal Alcohol Spectrum Disorder
Care Action Network

FASD and Choline

Choline is a vital nutrient required for many of our bodies' most basic functions. Interesting new research has been exploring its potential to reduce the impacts of prenatal alcohol exposure (PAE), and the symptoms associated with Fetal Alcohol Spectrum Disorder (FASD).

FASD is a diagnostic term used to describe the lifelong impacts on the brain and body of people who were prenatally exposed to alcohol. These impacts can lead to a range of challenges in daily living, affecting areas such as physical health, learning, memory, attention, communication, emotional regulation, and social skills. Recent science suggests choline supplementation is a promising, low-risk nutritional intervention that may lessen some of these neurodevelopmental harms.

Medical Disclaimer: This information sheet is for general knowledge and informational purposes only, and does not constitute medical advice. Always consult with a qualified medical professional before making any decisions about your or your child's health or before starting any new supplement regimen.

What is Choline?

As an essential nutrient, choline is needed by our bodies to function optimally, but it cannot produce enough of it on their own.[1] It is available in both foods and as supplements, and plays a crucial role in several bodily processes.

- **Brain development and function:** Choline is a building block for acetylcholine, a key brain chemical involved in memory, mood, and muscle control. It's also vital for the healthy development and function of the brain and nervous system.[2]
- **Cell structure:** It is a component of cell walls, which are essential for building and maintaining healthy cells throughout the body.[2]
- **Liver function:** Choline helps in the transport and metabolism of fats and cholesterol, preventing fat build-up in the liver.[2]
- **Gene regulation (Epigenetics):** Choline is involved in 'methyl donation', a process critical for making new DNA, turning genes on and off. This process is fundamental for optimal growth and development. [2]

Choline and Pregnancy

Choline is particularly important during pregnancy because of its critical role in the healthy development of the fetal brain and spinal cord. The demand for choline significantly increases during this period to support the rapid growth and development of the baby.

Concerningly, recent research led by Dr Hunter G. Petry (2024) has found that less than 50% of many non-prescription and prescription prenatal supplements contain adequate amounts of choline (and iodine).[3][4] This finding suggests that many pregnant women may not be getting enough choline through supplements alone. Inadequate choline levels may include an increased risk of neural tube defects, impaired fetal brain development and cognitive function, potential adverse pregnancy outcomes, and compromised maternal liver health. [3][4][5]

A "Functional insufficiency"

New research from 2025 suggests that alcohol exposure may create a "functional choline insufficiency." Alcohol may increase the demand for choline in both the liver and the placenta, meaning even a standard healthy diet may be inadequate during an alcohol-exposed pregnancy.[5][6]

The Protective "Shield"

Recent research also indicates that choline may act as a 'shield'. It may help prevent the type of cell death in the early stages of brain development (the neural tube) that can be caused by alcohol exposure.[6] Further research in larger animal models (like sheep) has shown that choline specifically protects the cerebellum (the part of the brain responsible for balance and coordination) by preventing the loss of critical 'Purkinje cells'. This shielding effect appears particularly strong during higher-level alcohol exposure.[7] This potential protection is often linked to how well the pregnant person's liver processes nutrients, showing how important overall health is during pregnancy. [6]

Natural Sources of Choline

While supplements are often needed to reach the levels used in research, eating foods high in choline is a great way to support health. It can be found in a variety of natural food sources and incorporating these into a balanced diet is beneficial:

- **Excellent sources:**
    - **Eggs:** Especially egg yolks, which are one of the most concentrated sources.
    - **Meat and Poultry:** Beef (especially liver, though consumed in moderation during pregnancy due to Vitamin A), chicken, and turkey.
    - **Fish:** Salmon, cod, and tuna.
- **Good sources:**
    - **Legumes:** Soybeans, kidney beans, peanuts.
    - **Dairy Products:** Milk, yogurt, cottage cheese.
    - **Vegetables:** Broccoli, Brussels sprouts, cauliflower, cabbage, potatoes, shiitake mushrooms.
    - **Grains/Seeds:** Quinoa, wheat germ, sunflower seeds.

Despite the presence of choline in these foods, studies consistently show that most pregnant people do **not** consume enough choline from their diet alone to meet the significantly increased daily recommendations (450-550 mg/day).[8][9] This gap highlights the possible need for choline supplementation during pregnancy to ensure adequate intake.

Types of Choline and their Uses: What does the research say?

Choline is available in various forms, both in foods and as supplements. While all forms provide choline, they can differ in how the body absorbs and uses them:

- **Choline Bitartrate:** This is the form most often used in FASD-specific clinical trials. It is a salt that the body absorbs well. Major studies, such as those at the University of Minnesota, used this form to help improve memory and attention in children.[2][5] It is a common and widely available form of choline found in many dietary supplements. As a good, well-absorbed source of choline, it's often used as a supplement to support liver health and brain function.

- **Phosphatidylcholine (Lecithin)**: This is the most abundant form of choline in foods (like eggs and soybeans) and is a major component of cell membranes. When consumed, it is broken down in the body to release choline. Lecithin supplements are often used for liver support and to help with fat metabolism. While it is healthy, it has less 'free' choline than the bitartrate form.
- **Citicoline (CDP-Choline):** This is often sold for 'brain health' in adults. This form is naturally occurring and is metabolised into cytidine and choline. It is thought to be particularly effective for brain health because both its components can cross the blood-brain barrier. Citicoline is often used in supplements aimed at improving memory, attention, and overall cognitive function. While it is useful, it has not been the main focus of research for young children with FASD.[10]
- **B-Vitamin Synergy:** Emerging research suggests that combining choline with other B-vitamins, such as **folate**, may provide superior results, as these nutrients work together to support the body's methylation processes.[11]

Choline Supplementation and FASD

Recent research suggests a significant link between alcohol exposure during pregnancy and the body's choline needs. Expert commentary suggests that choline serves as a critical, accessible intervention that may help "rescue" brain development following alcohol exposure.[12] Foundational animal research (2010) provided the first causal proof that choline supplementation can directly mitigate behavioural challenges caused by alcohol exposure.[13] This study was significant because it showed that choline could reduce overactivity (hyperactivity) and improve spatial learning and executive function, providing a scientific basis for the hope offered to whānau. The need for choline may be even greater in pregnant people who consume alcohol because:

- **Alcohol interferes with choline metabolism and absorption:** Alcohol can directly disrupt how the body uses and takes in choline, making it less available.
- **Choline redirection:** Alcohol exposure can divert choline to making fat, making it less available for critical development processes like methyl donation, gene regulation, and new DNA synthesis.[5] This redirection may worsen alcohol's impacts on the developing fetus.
- **Increased deficiency:** Pregnancy already increases demand on a person's choline stores. Alcohol consumption adds to this need, increasing the risk of a more severe choline deficiency and potentially worsening negative impacts on the developing fetus.[5][14]

Studies exploring the benefits of choline supplementation for people affected by FASD indicate promising results - particularly in improving brain function - both during and after pregnancy. [2]

Key Benefits Noted in Choline Research

Choline supplementation is a promising, low-risk intervention. Recent systematic reviews (2025) conclude with moderate certainty that prenatal supplementation improves memory outcomes.[15] More generally it has shown positive effects on brain function, especially when administered in the early toddler years (**specifically between 2-3 years of age**). [2][14] This research finding suggests that giving choline during this early period could be most effective in improving brain function and reducing learning and developmental difficulties related to alcohol exposure before birth. These benefits occur through several mechanisms directly impacting the Central Nervous System (CNS) – the brain and spinal cord:

- **Supporting brain chemistry and structure:** Choline is a building block for important brain chemicals like acetylcholine, which is crucial for memory, attention, and learning. It also helps form essential parts of brain cells, contributing to healthy brain structure and communication within the CNS.[2][9]
- **Influencing gene activity (Epigenetics):** Choline acts as a 'methyl donor', which means it can influence how genes are turned on or off (a process called epigenetics). Prenatal alcohol exposure can disrupt these gene control processes, leading to problems with the brain and spinal cord. Choline supplementation may help normalise these patterns, supporting optimal brain development and function within the CNS.[2][9]
- **Enhancing memory centres:** The hippocampus, the brain's main memory area, is particularly vulnerable to alcohol exposure. Choline may improve the development and function of this area, leading to better memory and cognitive abilities. [2][9]
- **Improving brain connections:** Research suggests choline may improve the organisation of 'white matter' in the brain. White matter is made of nerve fibres that connect different parts of the brain, forming crucial pathways within the CNS. Better organisation leads to more efficient brain communication and processing.[9] Importantly, a major long-term follow-up study (2022) demonstrated that children who received choline between the ages of 2 and 5 showed better-organised white matter in the corpus callosum years later, which was associated with improved memory and non-verbal intelligence.[16]
- **Strengthening Global Cognition:** A 2025 meta-analysis (Lino et al.) confirms that choline supplementation significantly improves global neurocognitive performance and visual-spatial memory in children with prenatal alcohol exposure, reinforcing its role as a robust evidence-based support.[17]
- **Reducing hyperactivity and improving attention:** Clinical trials have observed that choline supplementation can lead to fewer symptoms of attention deficit hyperactivity disorder (ADHD) and improved attention in young children with FASD. [9][13][14] These are direct improvements in CNS-related behavioural and cognitive functions.

Additional Noted Benefits

Research also indicates that choline supplementation during pregnancy can play a protective role in fetal brain development, particularly when there has been prenatal alcohol exposure. These effects are directly on the developing Central Nervous System:

- **Protecting brain structure and function:** Choline is vital for building brain cells and forming neural pathways within the CNS. Studies suggest that prenatal choline supplementation can help increase the volume of certain brain structures, such as the corpus callosum, thalamus, caudate, and putamen, which are often affected in FASD. [2][6][7][16][18] It also influences how genes are expressed (epigenetics) and helps in the formation of cell membranes, which are crucial for brain development and communication between brain cells in the CNS. [2][5]
- **Improving cognitive outcomes:** Higher maternal choline levels during pregnancy have been linked to improved cognitive development in children, including faster information processing in infants and better sustained attention in childhood,[5][14][19] and improved non-verbal intelligence and memory.[16][17] These are critical functions of the developing CNS.

- **Supporting physical growth (Reducing growth restriction):** Some research indicates that maternal choline supplementation can help protect against growth restriction in infants who were exposed to alcohol before birth.[2][6] In this context, 'growth restriction' means the baby's physical frame is smaller than expected. This can include lower birth weight, shorter length, and a smaller head size. Because alcohol can cause some cells to die off in the early stages of development, choline can act as a building block to help preserve these cells. This potentially supports the baby to grow to their full physical potential.[2][6]
- **Sleep regulation:** Emerging evidence suggests choline may support the regulation of circadian rhythms, which may help whānau struggling with stable sleep-wake cycles.[20]
- **Buffering stress:** Adequate choline may provide a 'buffer' for the baby's brain, potentially protecting neurodevelopment even when the pregnant person faces significant stress or illness. [21]

The "Critical Window" and Genetic Factors

While prenatal supplementation likely produces the greatest impact, early childhood intervention (ages 2–5) still shows significant promise. Benefits may be reduced if initiated later in childhood (ages 5–10).[2][8][14][15][19] Evidence from long-term follow-ups suggests that interventions within this early childhood window can lead to enduring structural changes in the brain that persist for many years.[16] New research also suggests specific genes (like the SLC44A1 gene) may determine how well a child responds to choline, pointing toward potential future "personalised nutrition" approaches.[22]

Choline Use in Infancy and with Toddlers

While more research is needed, some studies have looked at the effects of choline supplementation in infants and toddlers who were exposed to alcohol during pregnancy:

- **Early learning and memory:** One study found that infants (at 6.5 months old) whose mothers consumed alcohol during pregnancy and received choline supplementation, showed improved basic learning mechanisms related to memory, such as in eyeblink conditioning. At 12 months, these infants also had improved visual recognition memory [8][14]. These improvements reflect positive effects on the developing CNS.
- **Mixed evidence:** Overall clinical evidence for choline supplementation in infants with FASD is still considered mixed, with some studies showing little-to-no benefits for neurocognitive and neurodevelopmental outcomes or brain structure, though side effects were generally minor [2][8]. This highlights that research is ongoing, and outcomes can vary depending on many factors such as individual genetic differences, variations in alcohol exposure, the specific dosage and timing of supplementation, and other lifestyle or environmental factors.
- **Developmental window for effectiveness:** Research suggests that while early intervention (specifically in the 2-3 year range) shows promise, the effectiveness of choline supplementation might be reduced or absent in older children. Some studies indicate that starting choline supplementation later in childhood did not show the same significant changes in cognitive function. This suggests a limited developmental window for treatment efficacy. [2][8][9][16] This suggests that the timing of intervention is critical to achieving the best results.

Dosage, Type, and Safe Use

While the research on choline supplementation for FASD is promising, it is important to understand that there is no universal answer regarding the correct dosage or the most effective type of choline for every person.

- **Type of choline in research:** In studies related to FASD, **choline bitartrate** has been a commonly used form of supplementation.[5] For example, one clinical trial used 1.25 grams of choline bitartrate (providing 500mg of choline) daily for nine months.[14] Other studies have explored dosages up to 2 grams (2000 mg) daily for maternal supplementation.[18]

- **General dosage recommendations for pregnant people:** The Adequate Intake (AI) for pregnant people is generally 450 mg per day. Some research suggests that taking up to 900 mg of choline daily during pregnancy may be more beneficial.[8] However, it's important not to exceed the Tolerable Upper Intake Level (UL) of 3,500 mg (3.5 grams) per day for adults, as higher doses can lead to side effects.[23]

- **Dosage-related issues and side effects:**
  - **Fishy Body Odour:** One of the most common side effects of high choline intake is a fishy body odour, caused by the breakdown of choline into trimethylamine (TMA).[8][23] *Practical Tip:* Splitting the daily dose into two or three smaller amounts can often stop this from happening.[23]
  - **Other Side Effects:** Excessive consumption (above the UL) can also lead to heavy sweating, increased salivation, vomiting, and low blood pressure. [8][23]
  - **Liver Damage:** In rare cases, extremely high doses have been associated with liver damage.[23]
  - **Cardiovascular Risk:** Some research suggests that very high intakes of choline may increase the risk of cardiovascular disease, potentially due to the conversion of choline to trimethylamine N-oxide (TMAO) by gut bacteria.[23] This area requires more research.

Sensory and Practical Delivery

Many children with FASD experience sensory processing sensitivities. Introducing a new supplement can be challenging.

- **Sensory friendly options**: For tamariki who struggle with pills or strong tastes, choline bitartrate powder can often be mixed into high-fat foods (like yoghurt or peanut butter), which may help mask any saltiness and support absorption.

- **Consistency over quantity:** For vulnerable families, focusing on a consistent, manageable routine is more effective than focusing on high-dose "perfection."

Aotearoa Context and Hauora

In Aotearoa New Zealand, we view health through the lens of *Hauora* (holistic wellbeing). Supporting a child with FASD involves nurturing their *Tinana* (physical health), *Hinengaro* (mental health), *Whānau* (family), and *Wairua* (spirit). Nutrition is a vital tool to support *Te Oranga* (wellbeing), managed as a shared journey with your health providers.

We acknowledge that the science is evolving and that every child in Aotearoa New Zealand is a unique individual. While choline is a promising supportive tool, it is just one part of the wider support system whānau need to thrive. This support system is most effective when it embraces a whānau-based approach to health and wellbeing, acknowledging that the flourishing of pēpi is inseparable from the

collective strength and support of the whole whānau. This includes ensuring stable environments, appropriate sensory support, and tailored early education interventions alongside nutritional management.

Advocating for your Child: Talking to Health Professionals

Caregivers, families and whānau often need support when discussing nutrition science with medical professionals. Here are suggested questions to bring to your GP or paediatrician:

- *"I have read recent research (e.g., Lino et al., 2025 and Wozniak et al., 2015) regarding high-dose choline as a low-risk intervention for brain development in FASD. Can we discuss if this is appropriate for my child?"*
- *"Recent studies suggest alcohol exposure creates a 'functional insufficiency' of choline. Would you be willing to review the University of Minnesota clinical trial protocols (500mg daily) to see if we can safely trial this?"*
- *"Given the evidence for long-term improvements in brain wiring (Gimbel et al., 2022), can we monitor my child's progress alongside a choline-rich diet or supplement?"*

Professional Advice is Essential

- **Medical Consultation is Essential:** Any consideration of choline supplementation, especially for a child, **must be done under the guidance of a medical professional**, such as a paediatrician or general practitioner (GP). They can assess your child's specific needs, considering factors like age, weight, and overall health.
- **Research as a Guide:** Research papers, such as those by Ernst et al. (2022) [2] and Petry et al. (2025),[5] and Thomas (2021),[12] Thomas (2010),[13] Gimbel et.al. (2022),[16] and Lino et.al. (2025) [17] provide detailed information on the dosage levels, duration of supplementation, and the forms of choline used in their studies (e.g., choline bitartrate). These can serve as valuable references for your medical professional.
- **Checking Supplements:** Choline supplements are readily available in health stores. However, it is vital to carefully check the amount of choline provided in any supplement to ensure it aligns with medical recommendations and to avoid inadequate or excessive intake.[2] Additionally, recent research has found that some prenatal supplements may contain measurable amounts of toxic metals such as arsenic, lead, and cadmium, with some products exceeding established purity limits.[5] It is recommended to choose supplements that have been tested by third-party labs for these contaminants.

General Food Advice during Pregnancy

It is also important to remember the general 'rules' about foods to avoid during pregnancy that could affect the baby's development (e.g. raw or uncooked meats, poultry and seafood, high mercury fish, raw or undercooked eggs, and unpasteurised dairy products and juices, etc.) To find out more about foods to avoid or limit during pregnancy, you can visit these sites:

- **Health New Zealand | Te Whatu Ora**: Provides comprehensive official guidelines on safe and healthy eating, activity, and supplements during pregnancy. Click here to visit: Safe and Healthy Eating in Pregnancy
- **Whānau Āwhina Plunket:** Provides comprehensive information on pregnancy nutrition, including foods to avoid. Click here to visit: Plunket - Pregnancy Nutrition

- **Whānau Āwhina Plunket (Te Reo Māori)**: Provides health and care information during pregnancy specifically for whānau, translated into **Te Reo Māori**, and focusing on the well-being (*Ko tō hauora*) of both the mother and baby (*pēpi*). Click here to visit: Ko tō hauora me te manaaki tō hapūtanga - Whānau Āwhina Plunket
- **New Zealand College of Midwives**: Provides detailed information on staying well during pregnancy, including advice on healthy foods, vitamins, and supplements like **Folic Acid and Iodine**. Click here to visit: Staying well during pregnancy - New Zealand College of Midwives
- **Ministry for Primary Industries (MPI) - New Zealand Government:** Offers specific food safety guidance for pregnant women in New Zealand. Click here to visit: MPI - Food safety and Pregnancy
- **Center for Disease Control and Prevention (CDC):** Offers detailed information on safer food choices for pregnant women to prevent foodborne illnesses. Click here to visit: Food Safety for Pregnant Women
- **Mayo Clinic:** Provides clear guidelines on foods to avoid or limit, including explanations for why certain foods pose a risk. Click here to visit: Week by Week - Pregnancy Nutrition
- **National Health Service (NHS) - UK:** Offers practical advice on foods to avoid and healthy eating during pregnancy. Click here to visit: Keeping Well - Foods to avoid during Pregnancy
- **Pregnancy Birth and Baby (Australia):** Provides a handy guide to food and drinks to avoid, focusing on Australian guidelines. Click here to visit: Pregnancy Birth and Baby

Key Summary of Choline, PAE, and FASD

The following points summarise the current scientific understanding and best-practice approach for whānau and professionals in Aotearoa New Zealand:

- **Prevention First:** Abstinence from alcohol remains the only certain way to prevent FASD. Alcohol is a teratogen—a toxic poison to the developing fetus—and no amount of alcohol is considered safe at any stage of pregnancy. Alcohol targets brain cells directly, disrupting their migration and survival.
- **Protective Support:** For pregnancies where alcohol exposure has occurred, research in animal models and human clinical trials confirms that choline provides a robust layer of nutritional support.[12][13]
- **Cellular Shield:** Choline acts as a physical 'shield' for the developing brain. It has been shown to prevent the loss of critical brain cells (such as Purkinje cells) in the cerebellum and support the health of the neural tube.[6][7]
- **Long-Term Benefits:** Early intervention is key. Supplementation during pregnancy or the early toddler years (ages 2–5) is linked to enduring improvements in memory, attention, non-verbal intelligence, and the brain's physical wiring.[14][16][17]
- **Part of a Holistic Plan:** Choline is not a "cure-all." It is a supportive nutritional tool that works best when part of a wider *Hauora* plan including stable environments, sensory support, and early education interventions.
- **Functional Necessity:** Alcohol creates a 'functional insufficiency' by diverting choline away from brain development. Higher doses (e.g., 900 mg/day for pregnancy) may be needed to offset this metabolic stress.[5][8]

- **Safe Delivery:** Choline bitartrate is the research-standard form. While low-risk, all supplementation should be managed by a medical professional to ensure appropriate dosage and to monitor for minor side effects like fishy body odour.[14][23]

Conclusion

This information underscores the critical role of choline as an essential nutrient, particularly during pregnancy, for healthy fetal brain development and overall well-being. While naturally present in various foods, pregnancy and alcohol exposure can negatively impact choline levels, highlighting the potential need for supplementation.

Research into choline's benefits for PAE and FASD is promising, suggesting it may help mitigate some of alcohol's adverse effects on the developing brain, especially when administered in early childhood. However, it's important to recognise that research outcomes can vary due to diverse factors such as genetics, alcohol exposure levels, and the specifics of study design.

When considering choline supplementation, it is paramount to consult a medical professional to determine appropriate dosages and the most suitable form of choline. Additionally, awareness of potential side effects and checking supplements for accurate nutrient content is crucial for safe and effective use. This approach will help people to make informed decisions to support maternal and child health.

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Additional Resources:

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