



FEEDING HEALTHY MINDS:

Maternal and Infant Nutrition and Children's Brain Development

TUESDAY, 29 OCTOBER 2013

The Royal College of Surgeons, 35-43 Lincoln's Inn Fields, London WC2A 3PE



9.00am – 9.30am	REGISTRATION AND REFRESHMENTS
9.30am – 9.35am	Welcome and Introduction – Chair <i>Professor John Stein (University of Oxford)</i>
9.35am – 9.50am	Early Life Nutrition and Mental Health: An Overview <i>Dr Alex Richardson (University of Oxford; and FAB Research)</i>
9.50am – 10.10am	The Essentiality of Omega-3 DHA for Human Brain Development, and the Implications for Maternal Nutrition <i>Professor Michael A Crawford (Imperial College, London)</i>
10.10am – 10.30am	The Diets of Mothers and Children – A Clinician's Perspective <i>David Rex (NHS Highland)</i>
10.30am – 11.00am	REFRESHMENT BREAK
11.00am – 11.40am	Omega-3 and the Brain: Fish and Seafood Intakes During Pregnancy and Children's Mental Development <i>CAPT Joseph R Hibbeln (National Institutes of Health, Washington, DC)</i>
11.40am – 12.00pm	Iodine status of pregnant women and cognitive outcomes in their children: Findings from the Avon Longitudinal Study of Parents and Children (ALSPAC) <i>Dr Sarah Bath (University of Surrey)</i>
12.00pm – 12.30pm	Speakers Panel – Questions and Discussion
12.30pm – 2.00pm	LUNCH
2.00pm – 2.40pm	Dietary Needs for Omega-3 During Pregnancy and Infancy: What do we Know, and What do we Need to Know? <i>Professor Sheila Innis (University of British Columbia)</i>
2.40pm – 3.00pm	Implications of Maternal and Infant diets for Children's Development and Mothers' Mental health: Updates from the ALSPAC Study <i>Dr Pauline Emmett (University of Bristol)</i>
3.00pm – 3.20pm	REFRESHMENT BREAK
3.20pm – 3.40pm	Making Dietary Recommendations for Omega-3: Science, Policy and Practice <i>CAPT Joseph R Hibbeln (National Institutes of Health, Washington, DC)</i>
3.40pm – 4.00pm	Evidence-Based Approaches to Improving Nutrition for Children and their Families – A Dietitian's Perspective <i>David Rex (NHS Highland)</i>
4.00pm – 4.30pm	Speakers Panel – Questions, Discussion and Closing Comments

Early Life Nutrition and Mental Health: An Overview

**by Dr Alex Richardson, Senior Research Fellow at the Centre for Evidence Based Intervention,
University of Oxford; and Founder Director of the UK charity, Food and Behaviour Research**

Nutrition is fundamental to mental as well as physical health, development and wellbeing. The evidence is now undeniable that diet plays an important role in most developmental and mental health conditions, including ADHD and related childhood developmental disorders; depression, anxiety and other stress-related conditions, and age-related cognitive decline and dementia. In the UK and other developed countries, mental disorders now contribute more to the overall burden of ill-health than do physical health disorders, and the associated cost burdens are already becoming unaffordable.

Substantial evidence now shows that nutrition and diet during pregnancy and early life can irreversibly alter an individual's lifetime risk for mental as well as physical health disorders. Along with other environmental factors (such as exposure to infection or environmental toxins), diet influences both physical and mental health and development via so-called 'nutritional programming' effects on gene expression. The first 1000 days from conception appear to be a critical time period for these effects of 'nurture' (environmental factors) on 'nature' (genetic inheritance). Poor diets during this critical period can therefore compromise brain development and functioning, raising the lifetime risks for a wide range of mood, behaviour and learning disorders.

In the UK and other developed countries, evidence shows that the diets consumed by many women of child-bearing age simply do not provide adequate intakes of some of the nutrients known to be essential to support optimal brain development. The importance of folic acid in early pregnancy to prevent neural tube defects is now fairly well-known, but the diets of many UK mothers-to-be are often lacking in other key nutrients crucial for brain development and function. These include iodine, the long-chain omega-3 fatty acids (EPA and DHA), and Vitamin D - all of which are found in fish and seafood, as well as both iron (for which red meat is the best source) and zinc (found in both red meat and seafood).

Greater awareness of the importance of nutrition and diet in early life is clearly needed among both policymakers and the general public - along with better education and training in these areas for all professionals working with mothers-to-be and young children - if we are to succeed in meeting the serious challenges presented by the currently increasing rates of mental health disorders at all ages.

Summary of key points

- The growing cost burden of mental health disorders has already overtaken that of physical health disorders in the UK and other developed countries.
- Good evidence shows that diet plays an important role in many mental health conditions, including ADHD and related childhood developmental disorders, depression and anxiety, and dementia.
- Nutrition in early life (pregnancy and infancy) is now known to have long-term implications for mental as well as physical health and development, via 'nutritional programming' effects on gene expression. It is not 'nature' versus 'nurture': instead, both interact to shape development.

- Essential nutrients critical for healthy brain development that are particularly likely to be lacking from the diets of many mothers-to-be include the long-chain omega-3 fatty acid DHA, iodine and Vitamin D, all of which are found in fish and seafood, as well as iron and zinc in many cases.
- An increased awareness of the fundamental role of diet in early life is essential among policymakers, practitioners and the general public if we are to tackle the growing challenges presented by the apparent 'epidemic' of mental health disorders.

About Dr Alex Richardson

Dr Alex Richardson is a Founder/Trustee of FAB Research and a Senior Research Fellow at the Centre for Evidence Based Intervention, University of Oxford, having previously been based at Oxford's Dept of Physiology, Anatomy and Genetics from 1987-2007. She is internationally known for her work on the role of nutrition in behaviour, learning and mood, and is one of the world's leading researchers on the influence of omega-3 and other dietary fats on mental health and performance, particularly in relation to developmental conditions such as ADHD, dyslexia, depression and schizophrenia. Her research has always been multi-disciplinary, and currently involves both experimental studies and nutritional treatment trials. Alex is much sought after as a speaker for public, professional and academic audiences both nationally and internationally. She has over 80 research publications to date, and is also author of 'They Are What You Feed Them'.

The Essentiality of Omega-3 DHA for Human Brain Development, and the Implications for Maternal Nutrition

by Professor Michael A Crawford – Imperial College London

Omega-3 DHA (docosahexaenoic acid) is a long-chain polyunsaturated fatty acid found in algae, fish and other seafood. DHA is an essential structural component of all cell membranes in the brain and nervous system, helping to maintain the fluidity needed for proper cell signalling. It is particularly critical for vision, making up 30-50% of the retina, as photo-receptor cells absolutely require DHA to convert light into an electrical signal. In addition, substances made from DHA play key roles in almost all biochemical signalling systems in the brain and body, including gene transcription, regulation and expression. Some derivatives of DHA are needed to form synapses – the connections between brain and nerve cells – while others help to protect brain and nerve cells from damage. Deficiencies of DHA also interfere with the functioning of almost all classical neurotransmitters (chemical messengers) including dopamine, serotonin and many others – as well as impairing both cardiovascular and immune system functioning.

To develop and function normally, the human brain simply must have adequate supplies of omega-3 DHA, and this is particularly important in early life, when the brain is first being formed. Deficiencies at this critical stage can compromise both neuronal migration (the movement of newly formed brain cells to their proper positions), and the growth and connectivity of brain cells. In the placenta, concentrations of the long-chain omega-3 and 6 (DHA and AA) are actively increased compared with those in maternal blood, reflecting their critical importance to the developing baby. However, unless mother's diet and/or body stores can meet these needs during pregnancy (and also breastfeeding, which involves further transfers to the developing baby), her own omega-3 status can be compromised along with that of her child, with negative effects on the health and wellbeing of both mother and infant.

Modern, western-type diets are seriously lacking in omega-3 fatty acids in general, however, and DHA in particular. In theory, some DHA can be synthesised from the shorter-chain omega-3 (ALA) found in some plant oils, but in humans this process is not reliable, making pre-formed DHA a dietary essential. The widespread lack of pre-formed DHA in modern diets helps to explain the dramatic increase in 'brain disorders' in all developed countries over recent years, the cost burdens of which now exceed those of physical health disorders. Much of this increase is likely to reflect excessive use of other dietary fats which compete with DHA, and reduced intakes of fish and sea food - the primary source of DHA as well as other nutrients critical for healthy brain development and functioning, such as iodine, zinc and Vitamin D.

Improving the nutritional status of women of childbearing age is key to improving the health of future generations. To reverse current trends and meet the needs of growing populations worldwide will require an increase in current dietary intakes of long-chain omega-3 that cannot be met from either fishing or aquaculture using current technologies. Sustainable sources of DHA derived directly from algae offer one potential solution that is already available, and further sources may be forthcoming from genetic modification of plants to produce long-chain omega-3, or sustainable farming of the oceans.

Summary of key points

- DHA is the most abundant omega-3 fatty acid in the brain. It is critical for both the structure and functioning of brain and nerve cells, particularly in the visual system, and DHA status influences numerous essential biochemical processes including gene expression.
- For these reasons, DHA is particularly important in early life, when the brain is first developing, and during pregnancy and breastfeeding, the needs of the growing baby must be met from mother's diet and/or body stores.

- Modern western-type diets are seriously lacking in DHA, however, as the main dietary sources are algae, fish and seafood. Shorter-chain omega-3 from plant sources cannot reliably be converted into DHA in humans, and so pre-formed DHA is a dietary essential.
- This relative lack of DHA in modern diets helps to explain the dramatic rise in 'brain disorders', which have now overtaken all other burdens of ill-health in the UK and other developed countries. Given that early life is such a critical period, with lifelong implications for mental as well as physical health, improving the nutritional status of women of childbearing age in particular must be recognised as an urgent public health priority.
- Increased supplies of DHA are needed to meet the needs of the growing world population, as the quantities needed to support human brain health cannot be met from fish stocks or conventional aquaculture. Some forms of algae already provide a sustainable, scalable source of DHA, although other approaches include genetic modification of plants and sustainable farming of the oceans.

About Professor Michael A Crawford

Professor Michael Crawford has been the Director of the Institute of Brain Chemistry and Human Nutrition since 1990. Having worked in the East-end of London on maternal nutrition and health with Newham, the Homerton and Queen Elizabeth Hospital for Children, he is now at Reproductive Physiology at the Chelsea and Westminster Hospital Campus of Imperial College, London. His special interest lies in the role that lipids and essential fatty acids play in interacting with the cellular signalling systems, i.e. the key interaction between nutrition affecting membrane lipids and gene expression. He has published over 300 peer reviewed papers and 3 books. Amongst his several honours and prizes, he was elected by his peers to the Hall of Fame at the Royal Society of Medicine in 2010. He collaborates in research internationally and is much in demand as a lecturer worldwide.

The Diets of Mothers and Children

A Clinician's Perspective

by David Rex, Dietitian, Health & Social Care – Children's Services, Highland Council, Inverness

This presentation will describe typical dietary habits seen in the Scottish Highlands and set this in the context of the many emotional, social, financial and commercial pressures that influence the food culture of parents and their children. Practical and strategic suggestions will be made for families, schools and other local institutions.

These suggestions are informed by the experience of working with schools to develop a whole school approach to food & health, and working with families to support them in their efforts to improve the food choices that they and their children make.

Key Points:

- Most parents know quite a lot about nutrition already, but they find it hard to “See the wood for the trees”
- What we know about food is not the same as how we feel
- The focus on “*too much*” disengages families, and fails to do justice to the inadequacy of many diets
- It's hard for parents or children to value food that they feel they ‘ought’ to eat
- Conflating health with weight is making things worse rather than better
- Well informed, emotionally literate and politically engaged children and families make better food choices

About David Rex

David Rex is a Dietitian for Highland Council, working in “Health & Social Care – Children's Services”. He has a lead public health role for Food & Health in schools, nurseries and Children's Residential Units; and provides specialist Dietetic advice for children with Autistic Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD). He advises on diet and children's mood, behaviour and learning; and on how to deal with the selective eating patterns that are so common in children with ASD. He has been heavily involved in the development of the “High 5” Health & Wellbeing programme for Highland primary schools, and is a member of the Highland School Meals Stakeholder group. David has a first degree in Chemistry and Food Science, a post graduate Diploma in Nutrition and Dietetics, and a Masters in Food Policy. He has over 25 years experience of the food system, starting as a “Teenage burger flipper” for a well known fast food chain, and going on to look at food and health from a range of different perspectives, in posts as diverse as: food chemist and technical advisor in the food industry; community and hospital dietitian; and food policy advisor for a Health Authority. He is an advocate for sustainable and socially just food systems, and is passionate about cooking and eating well.

Omega-3 and the Brain: Fish and Seafood Intakes During Pregnancy and Children's Mental Development

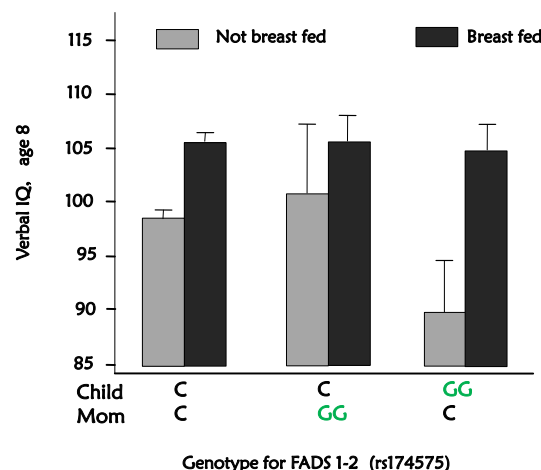
CAPT Joseph R Hibbeln (National Institutes of Health, Washington, DC)

Optimal child development requires a combination of good genetic inheritance, loving and supportive families and optimal nutritional substrate for the brain to grow on. Specialized fats comprise 60% of the brain and are critical for adequate neurological function. Surprisingly many nutrients can be obtained only from our foods. Inadequate intakes of these essential nutrients, specifically omega-3 highly unsaturated fatty acids (omega-3 HUFAs,) impair critical processes in brain development such as the growth of neurons in developing their full complexity of dendritic arborization (ie branching and connections with other neurons) and levels of fundamental neurotransmitters. Modern diets contain few of these omega-3HUFAs, but contain excessive omega-6 fats that are common in processed foods. Inadequate intakes of fish and seafood during pregnancy, a rich source of omega-3 HUFA, is associated with an increased risk of low IQ and behavioral problems in children. The risk of low IQ and behavioral problems due to avoiding fish consumption during pregnancy appear to be much greater than the potential risks attributable to exposure to small amounts of methyl-mercury from fish. For example, we estimate that among US women who consume the greatest amount of fish, their children would have lost nearly 5-6 IQ points due to nutritional deficiencies if they had avoided fish, but gained only 0.01 IQ points from less exposure to methyl-mercury.

Fish are rich in multiple nutrients, thus it is important to determine if the suboptimal development of the children is specifically due to inadequate omega-3 HUFAs, as opposed to other nutrients. We did this by examining the effects of the FADS gene. 12.5% of the children carry a variant of this gene that does not allow efficient production of omega-3 and omega-6 HUFAs from their precursors, α -linolenic (ALA) and linoleic acids (LA) respectively. Breast milk contains preformed omega-3 and omega-6 HUFAs and among breast fed children we could see no effect of which FADS variant they had on their IQ. Whether they could make enough on their own appeared to be irrelevant. In contrast, infant formulas available at the time did not contain omega-3 or n-6 HUFAs, but only contained their precursors, LA and ALA respectively. Among exclusively infant formula fed infants, the variant of the FADS genes did make a difference of an additional 5.8 points [95% CI 1.4, 10.1] (interaction $p=0.0091$).

Breastfeeding, FADS 1-2, and child IQ age 8

Maternal child pairs of white European origin. Adjusted for relevant social confounders.





About CAPT Joseph Hibbeln

CAPT Joseph R Hibbeln, MD is the Acting Chief, Section of Nutritional Neurosciences, Laboratory of Membrane Biophysics and Biochemistry, National Institute on Alcohol Abuse and Alcoholism NIH, Bethesda Maryland. Dr Hibbeln is internationally recognized as originating the field of omega-3 fatty acids in depression and impulsive disorders and his contributions toward understanding nutrition in mental health. The Dietary Guidelines for Americans 2010, and numerous international agencies have cited his work as foundational in developing dietary advice. Dr Hibbeln is the recipient of numerous awards including the Wilhelm Normann Medal in 2012. He has published more than 120 peer-reviewed scientific papers. He is board certified physician in psychiatry and serves as a Captain in the United States Public Health Service (USPHS).

**Effect of inadequate iodine status in pregnant women on cognitive outcomes in their children.
Findings from the Avon Longitudinal Study of Parents and Children (ALSPAC)**

**Dr Sarah Bath, (Post-doctoral Research Fellow, Department of Nutritional Sciences,
Faculty of Health and Medical Sciences, University of Surrey)**

Iodine is required for the production of thyroid hormones, T4 and T3, and these hormones are required for the regulation of metabolic rate, growth and development. A sufficient intake of iodine during pregnancy is vital for the brain and neurological development of the fetus which is dependent on the action of thyroid hormones. The WHO recommended iodine intake for adults (>12 years) is 150 µg/day and it is important that women of childbearing age meet their iodine requirement prior to conception to ensure that they have adequate thyroidal iodine stores.

During pregnancy and lactation, the requirement for iodine rises from 150 to 250 µg of iodine per day to ensure adequate thyroid hormone production for both the mother and the fetus. A deficiency of iodine during pregnancy can lead to impaired brain development with consequences for the intelligence and school performance of the child in later life.

We have recently shown that a low iodine status in early pregnancy is associated with lower IQ and reading scores in the child up to the age of nine years. This study involved the measurement of iodine status in 1040 pregnant women who were recruited to the Avon Longitudinal Study of Parents and Children (ALSPAC); we related iodine status in the mother to the IQ and reading scores in their children up to the age of nine years. We found that low iodine status during early pregnancy (urinary iodine/creatinine ratio <150 µg/g) was significantly associated with the child being in the bottom quartile of scores for verbal IQ at age 8 (OR 1.58, 95% CI 1.09–2.30; p=0.02), reading accuracy (OR 1.69, 95% CI 1.15–2.49; p=0.007) and reading comprehension (OR 1.54, 95% CI 1.06–2.23; p=0.02) at age 9 years, following adjustment for up to 21 confounding variables (e.g. preterm birth, breastfeeding and maternal education).

Iodine deficiency was historically common in the UK, with a goitre belt that extended from the West Country and included Derbyshire, where goitre was so common it was called “Derbyshire neck”. Iodine deficiency persisted until the 1960s but was subsequently eradicated, not by the usual practice of an iodised-salt programme, but through an adventitious increase in milk-iodine concentration and concurrent increase in milk consumption. Subsequently the UK was considered to be iodine sufficient, however in recent years there has been increasing evidence to suggest that certain subgroups, particularly young women and pregnant women, are iodine deficient.

The main dietary sources of iodine are milk and dairy products, contributing up to 40% of adult intake of iodine. Fish, although a very concentrated source of iodine, contributes a smaller percentage (approximately 11%), largely as a result of its low popularity in the UK. Other dietary sources include eggs. Seaweed has a very high concentration of iodine, particularly brown seaweeds such as kelp and as a result, kelp and seaweed supplements are not recommended, owing to the risk of consuming excessive iodine intake.

Key messages

- Iodine is vital during pregnancy and lactation
- A deficiency of iodine during pregnancy can affect brain development and can lead to poorer cognition in childhood e.g. IQ and reading ability
- Pre-pregnancy stores of iodine are important; any woman of childbearing age, and especially those who are planning a pregnancy, should ensure that they get enough iodine in their diet
- Milk and dairy products are the main source of iodine in the UK diet
- Other important sources include seafood (i.e. white fish, oily fish and shellfish) and eggs
- Seaweed or kelp supplements should **not** be used as an iodine source. This is because the amount of iodine in the supplement can vary considerably from the value claimed on the label and can provide excessive quantities of iodine

About Dr Sarah Bath

Dr Sarah Bath is a registered dietitian and post-doctoral research fellow at the University of Surrey. She graduated from here in 2007 with a first class honours degree in Nutrition and Dietetics and, after working as a dietitian in the NHS for 18 months, she returned to the University to undertake a PhD under the supervision of Professor Margaret Rayman. She has studied an under-researched area in the UK - the iodine status of UK pregnant women and the food sources that contribute to iodine status. Through collaboration with the Avon Longitudinal Study of Parents and Children (ALSPAC), she has found that mild-to-moderate iodine deficiency in UK pregnant women is associated with adverse cognitive outcomes in the child. Sarah is passionate about translating her research into practical advice and has worked with the British Dietetic Association to produce a "Food Fact" sheet on iodine. She has recently been awarded a MRC Population Health Scientist fellowship to continue her work on iodine.

Dietary Needs for Omega 3 During Pregnancy and Infancy: What Do We Know and What Do We Need to Know?

**By Professor Sheila M Innis, Department of Paediatrics,
University of British Columbia, Vancouver, Canada**

The omega-3 fatty acid docosahexaenoic acid (DHA) is a crucially important component of the brain and the visual elements of the retina. Inadequate DHA during early stages of development can impair fundamental aspects of brain, with the possibility of deficits that may have long-lasting implications for the child.

Understanding whether omega-3 fatty acid inadequacy contributes to failure of children to reach their developmental potential or alters behaviour is crucially important, but also complex. Questions and information needed to address dietary needs for omega 3 fatty acids during pregnancy and infancy can be grouped in three general areas.

First, is the type and amount of the different omega 3 fatty acids in our diets, and interactions with other fatty acids, such as the omega 6 fatty acids which might alter omega-3 needs. DHA is consumed in the diet, but only in animal lipids, mainly from fish. DHA can also be synthesized from the omega-3 precursor α -linolenic acid (ALA) found in some plant oils and nuts, but this requires specific enzymes.

Second, is the question of how much DHA is needed, how this changes at different life stages, and how to assess this before and after birth.

Finally, we need to recognize that not all individuals are the same. Increasing evidence shows that population specific genetic differences arising from natural selection to the indigenous food supply in different geographic regions has shaped the interplay between foods, lifelong health and disease risk. This final point becomes particularly important as populations migrate, the boundaries of culturally specific diets become increasingly blurred, and many subsist on diets highly dependent on processed and prepared foods.

An alternate approach is first to consider whether sufficient evidence exists to conclude that women, their infants and children following modern, westernized diets are at increased risk of DHA inadequacy sufficient to increase risk of poor brain development and altered neurological function. This would warrant advice for DHA intake to reduce disease burden, while not necessarily demanding precision of dietary requirements or how many milligrams are needed to avoid deficiency.

Observation studies have linked higher fish or DHA intake during pregnancy and lactation to better child neurodevelopment. Randomized interventions of fish oil or other sources of DHA in pregnancy and lactation, however, have yielded conflicting or null findings. Problematic, it is not known if any, some, or all individuals in these studies were deficient.

Our work uses a risk reduction model to answer the question of whether DHA insufficiency is present among pregnant women and constrains neural development in infants. A fundamental concept is that only individuals who are deficient will benefit from DHA; a null response means that individuals have adequate status, not that DHA is unimportant. We gave 400 mg/day DHA or a placebo from 16 weeks of

gestation until infant delivery. DHA supplementation increased maternal blood DHA in gestation by 35-40%. Infants of mothers not given DHA were less likely to score in the highest quartile on neuro-developmental tests, particularly in domains associated with language. Our work shows that DHA insufficiency occurs in the population, and constrains (slowed) infant neural development.

While it is clear dietary DHA reduces risk, the cause remains unclear. It may be simply that some individuals are unable to form sufficient DHA from plant derived ALA, or that high omega 6 or other factors, such as genetic variation interfere with how the body uses omega 3. This leaves the choice of experts providing dietary guidance to await answers from a likely insurmountable task of defining dietary requirements for DHA based on knowledge of estimated average requirements, or to adopt risk reduction by recommending intakes that pose no harm to the population but reduce risk of deficiency among those who are vulnerable, whatever the cause.

Summary of Key Points

- DHA is an important component of the brain, retina and some other tissues.
- DHA can be synthesized in the body from ALA or consumed in animal fats, particularly fish.
- DHA deficiency will occur when the ability for DHA synthesis from ALA is insufficient to meet the body needs for DHA in individuals not consuming DHA equivalent to or above their needs.
- Our work shows that DHA deficiency occurs is associated with poorer child development, and that risk of deficiency is reduced by consuming DHA.

About Professor Sheila Innis

Professor Sheila Innis MD is a Professor in the Department of Paediatrics, Faculty of Medicine at the University of British Columbia, and Director of the Nutrition and Metabolism Program at the Child and Family Research Institute. Her research and academic career in nutrition, growth and development relates largely to the role of lipids and essential fatty acids. She has over 170 peer-reviewed publications and has been continuously funded by the Canadian Institutes of Health Research (CIHR). Her research focuses on the role of dietary fat in providing essential fatty acids to support growth and development, including long-term effects on children's physical, cognitive and behavioural health. Sheila is investigating how specific fatty acids influence brain development and nerve function and the dietary intakes needed to ensure optimal development to affect our life-long susceptibility to disease.

Implications of Maternal and Infant diets for Children's Development and Mothers' Mental health: Updates from the ALSPAC Study

Dr Pauline Emmett, Senior Research Fellow, Nutritionist & Dietitian

This presentation will use the ALSPAC data collected on 14,000 pregnant women in the Bristol area of the UK in 1991-92 and following their children to age 15 years.

It will show how food frequency questionnaires were used to assess fish eating and dietary pattern types in the women during pregnancy and the children at age 3-7 years.

Fish eating was associated with higher DHA levels in the women's blood. Polyunsaturated fatty acids in the diet were mainly omega-6 and in the small amount of omega-3 fatty acids consumed, very little were in the active forms (DHA & EPA). Omega-6 fatty acids were mainly from processed foods while omega-3 fatty acids were mainly from fish. Of the most commonly consumed vegetable oils, rapeseed oil (canola) has more omega-3 and less omega-6 than others, but the omega-3 in these is the short-chain form (ALA) which does not have the same health benefits as DHA and EPA.

The well being of mothers' during pregnancy was assessed by questionnaire, and high levels of depressive and anxiety symptoms were defined and compared to levels of omega-3 intake from fish. Higher levels of both types of symptoms were associated with a low intake of seafood. Higher levels of anxiety symptoms were also associated with eating a 'vegetarian' type of diet even after controlling for seafood intake and educational status. Lower levels of anxiety symptoms were associated with eating a 'traditional' type of diet or a 'healthy' type of diet.

Children's visual development was assessed as a window into the brain using standardized methods in a clinic setting at several ages. At 3.5 years better depth vision was associated with being breastfed and with the mother eating oily fish in pregnancy. The development of vision is not associated with the mother's educational status, so this is likely to be a true finding. At age 7.5 years the child's intake of oily fish was more important than the mother's intake in pregnancy and whether the child was breastfed or not. At each age up to 15 years, eating oily fish was beneficial to the development of depth vision in the children.

Key Points:

- Eating fish and seafood - especially oily fish - at least once a week is beneficial both in pregnancy and childhood.
- Mother's own mental wellbeing is improved by eating fish and seafood.
- The overall type of diet a mother eats is also important for her mental wellbeing; eating a vegetarian style diet is not as beneficial as eating a more mixed diet with some fish and meat/poultry.
- For non-fish eaters, it is important to obtain omega-3 fatty acids from other dietary sources because they are essential to health. Some vegetable oils (notably flax but also rapeseed (canola) oil, walnuts and some other nuts and seeds) contain short-chain omega-3 (ALA) – but this does not convert well to DHA. Some types of poultry and eggs also contain omega-3. This too is usually ALA, but some fortified foods or supplements now provide DHA from algae.

About Dr Pauline Emmett

Dr Pauline Emmett is a Senior Research Fellow at the Centre for Child and Adolescent Health in Bristol University. She is an experienced research Nutritionist and Dietician and was head of Nutrition Research for the Avon Longitudinal Study of Parents and Children (ALSPAC) for 15 years. Since 1993 she has been working in the area of nutrition and diet in pregnancy and childhood and is particularly interested in early growth and development of children and early diet. Her PhD from Bristol University involved research into childhood diet. She has published many scientific papers using data from ALSPAC. She has personal experience of bringing up two children so has tested out some of the theory and can provide practical as well as scientific knowledge. She has extensive experience of communicating the scientific message to the general public and regards this aspect of her work as very important.

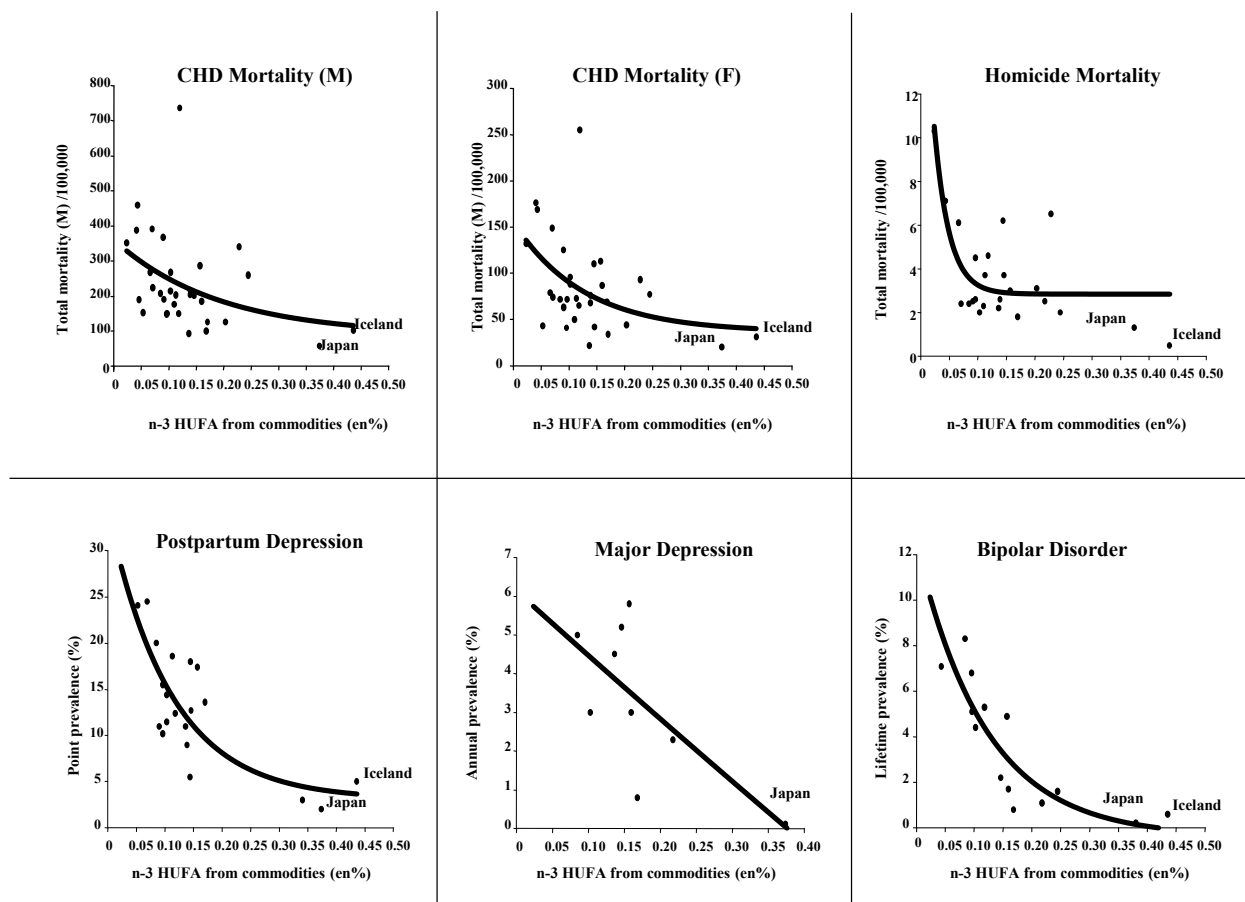
Making Dietary Recommendations for Omega-3: Science, Policy and Practice

CAPT Joseph R Hibbeln (National Institutes of Health, Washington, DC)

The process of determining a dietary recommendation is complex, but three criteria serve as useful endpoints:

1. the percentage of the population protected,
2. the reduction in chronic disease, and
3. the consideration of tissue compositions.

For example, a US Recommended Dietary Allowance functions as a subgroup of the Dietary Reference Intake and is defined as the “average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97–98%) healthy individuals in a particular life stage and sex group”. In the past, dietary allowances were developed with the goal of preventing signs or symptoms of severe deficiency. In the 2005 guidelines for Dietary References Intakes, the Institute of Medicine required that “reduction in the risk of chronic degenerative disease [be] included, rather than simply preventing scaly dermatitis or skin atrophy, as is the case for LA. To meet this definition we considered reducing risk for mental illnesses as well as decreasing the risk of mortality in developing nutrient requirements for omega-3 HUFAs.



Hibbeln et al Am J Clin Nutr 2006; 83; 1483S-93S

Here deficiency in omega-3 HUFAs was defined as attributable risk from 13 morbidity and mortality outcomes, including all causes, coronary heart disease, stroke, cardiovascular disease, homicide, bipolar disorder, and major and postpartum depressions. Dietary availability of omega-3 HUFAs from commodities for 38 countries and tissue composition data were correlated by best fit to each illness in deficiency risk models.

The relationship of dietary omega-3 and omega-6 fats on body composition of omega-3 HUFAs

Lower background dietary intakes of the omega-6, below 4 % of energy, decrease the amount of omega-3 HUFAs need in the diet in order to achieve more optimal tissue levels. For example, omega-3 HUFA intakes needed to meet a tissue target representative of Japan (60% omega-3 in HUFA) ranged from 278 mg/d (Philippines, with intakes of 0.8% of energy as linoleate, 0.08% of energy as α -linolenate, and 0.06% of energy as arachidonic acid) to 3667 mg/d (United States, with 8.91% of energy as linoleate, 1.06% of energy as α -linolenate, and 0.08% of energy as arachidonic acid). We can find no randomized controlled trials using omega-6 specific interventions that demonstrate protection from cardiovascular death. We can only find an increased risk of CVD mortality.

Finally, current advice in the 2010 Dietary Guidelines for Americans is for the consumption of fish 2-3 meals per week. This recommendation is consistent with our estimations of a minimum of 1 gm omega-3 HUFAs per day to reduce risk of major depression and other mental illnesses.

Dietary requirements for EPA and DHA increase by 13-fold with high background intakes of LA (18:2n-6)

	n-3 HUFA intake required to meet Japanese tissue target		+ Background dietary intake (en%)				= Tissue target (Mature Japanese)	
COUNTRY	(mg/d)	(en%)		LA 18:2n-6	AA 20:4n-6	a-LNA 18:3n-3	% n-3 in HUFA	Omega-3 index
Philippines	278	0.125	+	0.80	0.06	0.08	60%	12
Denmark	1,000	0.45	+	2.23	0.09	0.33	60%	12
Iceland	1,200	0.54	+	2.48	0.10	0.33	60%	12
Colombia	1,133	0.51	+	3.21	0.04	0.24	60%	12
Ireland	1,378	0.62	+	3.57	0.06	0.42	60%	12
UK	1,600	0.72	+	3.91	0.07	0.77	60%	12
Netherlands	1,956	0.88	+	4.23	0.08	0.28	60%	12
Australia	2,000	0.90	+	4.71	0.07	0.49	60%	12
Italy	2,111	0.95	+	5.40	0.06	0.51	60%	12
Germany	2,222	1.00	+	5.57	0.06	0.62	60%	12
Bulgaria	2,778	1.25	+	7.02	0.05	0.06	60%	12
Israel	3,222	1.45	+	7.79	0.07	0.67	60%	12
USA	3,667	1.65	+	8.91	0.08	1.06	60%	12

Hibbeln et al Am J Clin Nutr 2006; 83; 1483S-93S

**About CAPT Joseph Hibbeln**

CAPT Joseph R Hibbeln, MD is the Acting Chief, Section of Nutritional Neurosciences, Laboratory of Membrane Biophysics and Biochemistry, National Institute on Alcohol Abuse and Alcoholism NIH, Bethesda Maryland. Dr Hibbeln is internationally recognized as originating the field of omega-3 fatty acids in depression and impulsive disorders and his contributions toward understanding nutrition in mental health. The Dietary Guidelines for Americans 2010, and numerous international agencies have cited his work as foundational in developing dietary advice. Dr Hibbeln is the recipient of numerous awards including the Wilhelm Normann Medal in 2012. He has published more than 120 peer-reviewed scientific papers. He is board certified physician in psychiatry and serves as a Captain in the United States Public Health Service (USPHS).

**Evidence Based Dietary Advice for Children's Mood, Behaviour and Learning,
In The Context of Healthy Eating Guidelines and Typical Eating Habits**

by David Rex, Dietitian, Health & Social Care – Children's Services, Highland Council, Inverness

This presentation will assess the degree to which the current "Levels of evidence" approach to dietary recommendations is fit for purpose – whether for the current dietary advice offered to mothers during pregnancy, or for other issues concerning children's mood, behaviour and learning.

A progressive alternative is suggested, based on many years of experience of a dietitian balancing parental interest in nutrition "therapy" and the promotion of a healthy food culture at the population level.

Key points:

- The current preferred way of assessing the value of dietary interventions is too reductionist to allow diet to be taken seriously. This particularly applies when evaluating dietary interventions for children with behaviour and learning difficulties such as ASD and ADHD, but equally applies to dietary advice for other issues, including pregnancy.
- The current interpretation of this "*Levels of evidence*" approach gives practitioners and families the idea that drugs are essential and a nourishing diet is unimportant.
- Our current assumption that the health professional is the "*expert*" means that parents' interest in the link between mood and food is often seen as a threat, instead of an opportunity for engagement.
- A more holistic and progressive form of decision making, using the full range of available evidence on nutrients, foods and diets, is proposed.
- This approach allows us to restore the natural hierarchy with diet at the top, supplements as second best, and drugs only when necessary.

About David Rex

David Rex is a Dietitian for Highland Council, working in "Health & Social Care – Children's Services". He has a lead public health role for Food & Health in schools, nurseries and Children's Residential Units; and provides specialist Dietetic advice for children with Autistic Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD). He advises on diet and children's mood, behaviour and learning; and on how to deal with the selective eating patterns that are so common in children with ASD. He has been heavily involved in the development of the "High 5" Health & Wellbeing programme for Highland primary schools, and is a member of the Highland School Meals Stakeholder group. David has a first degree in Chemistry and Food Science, a post graduate Diploma in Nutrition and Dietetics, and a Masters in Food Policy. He has over 25 years experience of the food system, starting as a "Teenage burger flipper" for a well known fast food chain, and going on to look at food and health from a range of different perspectives, in posts as diverse as: food chemist and technical advisor in the food industry; community and hospital dietitian; and food policy advisor for a Health Authority. He is an advocate for sustainable and socially just food systems, and is passionate about cooking and eating well.

About FAB Research

Food and Behaviour Research, established in 2003, is a charitable organisation dedicated both to advancing scientific research into the links between nutrition and human behaviour and to making the findings from such research available to the widest possible audience.

FAB Research aspires to be a local and international leader of scientific research into how nutrition affects the human brain and mind, and an intellectual and strategic force for improving public education and professional practice in this domain. Our main aims are:

- To support and promote world-class scientific research into nutritional influences on brain and behaviour, which often spans the current boundaries between many different academic and professional disciplines.
- To provide accessible, evidence-based information to other researchers, the public, practitioners and policymakers on the importance of nutrition and diet to brain development and function.

NEW – The FAB Research Audio/Video Library



Today's event is being filmed and recorded, and will be available to view in the FAB Research Audio/Video Library, approximately one month after the event.

This Library is a new resource where FAB Research Associate Members may access audio and video material, and other accompanying resources from FAB Research events.

Current content includes presentations from three recent FAB Research conferences, including full video and slide presentations from:

- **'Sugar, Fat and the Public Health Crisis'** – a special FAB symposium featuring Professor Robert Lustig MD, US paediatric obesity specialist and endocrinologist, and widely known author of 'Fat Chance: The bitter truth about sugar'.
- **'Changing Diets, Changing Minds: The Importance of Nutrition for Behaviour, Learning and Mood'** - including among others, presentations from Dr Bernard Gesch (Nutrition and Antisocial behaviour), Professor Michael Crawford (Dietary Fats and Brain Development), Kevin Williamson (Dietary Interventions for Adult Mental Health).
- **'Omega-3 DHA for Child Behaviour and Learning: New Insights from the DOLAB Studies'** – featuring presentations of new data from the school studies by Dr Alex Richardson and Professor Paul Montgomery of Oxford University.

If you would like to access this resource and hear the full presentations given by the speakers from our 2013 events:

Please join us as an Associate Member of FAB Research
(see overleaf for details)

FAB Research Associate Membership – Benefits and How to Join

When you become a FAB Research Associate, you will be helping to support our work in providing evidence-based information on the role of nutrition in behaviour, learning and mood, and helping to ensure that this information reaches as wide an audience as possible.

In addition, the benefits to you include:

- Unrestricted access to the FAB Research Audio/Video Library
- Reduced prices on selected titles in the FAB Bookstore
- Greatly reduced delegate rates for seminars, conferences and other events organised by FAB Research
- Regular email updates

Associate Membership Levels and Annual Subscription Costs

The following apply for UK-based Associates (please see the FAB website for rates applicable to those based in other countries).

- Corporate/Industry: £295 (to include 6 organisational/corporate members)
- Educational and not-for-profit organisations: £295 (to include up to 30 student/staff members)
- Individual: £49
- Full Time Student:* £29

* Please let us know course title and name of your University/College/School by emailing admin@fabresearch.org.

Help us to spread the word

If you have found our work useful:

Please tell others about FAB Research, and encourage them to join us if they can.

Direct them to our website **www.fabresearch.org** and encourage them to sign up for our Free Email Alert service.

And please sign up yourself to stay up-to-date.



**Feeding Healthy Minds:
Maternal and Infant Nutrition and Children's Brain Development
Tuesday, 29 October 2013
Speakers and Chair**

Professor John Stein is a Professor of Neurophysiology, University of Oxford, Fellow of the Royal College of Physicians and Chair of the Dyslexia Research Trust. He studied Medicine and Neurology and was appointed tutor in Medicine at Magdalen College, Oxford. John is internationally known for his studies of attentional and eye movement control in dyslexia and related conditions which have shown that mild impairments in the development of magnocellular neurones in the brain may explain memory, auditory and visual problems associated with dyslexia. He has developed simple treatments, such as coloured filters and omega-3 fish oils, to improve their function and thus greatly improve dyslexics' reading without endangering their artistic talents. His daughter, Lucy, is a painter. John doesn't cook fish and his brother, fish chef, Rick Stein, does not do neuroscience!



Dr Alex Richardson is a Founder/Trustee of FAB Research and a Senior Research Fellow at the Centre for Evidence Based Intervention, University of Oxford, having previously been based at Oxford's Dept of Physiology, Anatomy and Genetics from 1987-2007. She is internationally known for her work on the role of nutrition in behaviour, learning and mood, and is one of the world's leading researchers on the influence of omega-3 and other dietary fats on mental health and performance, particularly in relation to developmental conditions such as ADHD, dyslexia, depression and schizophrenia. Her research has always been multi-disciplinary and currently involves both experimental studies and nutritional treatment trials. Alex is much sought after as a speaker for public, professional and academic audiences nationally and internationally. She has over 80 research publications and is also author of 'They Are What You Feed Them'.

Professor Michael Crawford - Director of the Institute of Brain Chemistry and Human Nutrition since 1990. Having worked in the East-end of London on maternal nutrition and health with Newham, the Homerton and Queen Elizabeth Hospital for Children, he is now at Reproductive Physiology at the Chelsea and Westminster Hospital Campus of Imperial College. His special interest lies in the role that lipids and essential fatty acids play in interacting with the cellular signalling systems, - the key interaction between nutrition affecting membrane lipids and gene expression. He has published over 300 peer reviewed papers and three books. He was elected by his peers to the Hall of Fame at the Royal Society of Medicine in 2010 and collaborates in research internationally. Michael is much in demand as a lecturer worldwide.



CAPT Joseph R Hibbeln, MD is the Acting Chief, Section of Nutritional Neurosciences, Laboratory of Membrane Biophysics and Biochemistry, National Institute on Alcohol Abuse and Alcoholism NIH, Bethesda Maryland. Dr Hibbeln is internationally recognized as originating the field of omega-3 fatty acids in depression and impulsive disorders and his contributions toward understanding nutrition in mental health. The Dietary Guidelines for Americans 2010, and numerous international agencies have cited his work as foundational in developing dietary advice. Dr Hibbeln is the recipient of numerous awards including the Wilhelm Normann Metal in 2012. He has published more than 120 peer-reviewed scientific papers. He is board certified physician in psychiatry and serves as a Captain in the United States Public Health Service (USPHS).

Professor Sheila Innis MD is a Professor in the Department of Paediatrics, Faculty of Medicine at the University of British Columbia, and Director of the Nutrition and Metabolism Program at the Child and Family Research Institute. Her research and academic career in nutrition, growth and development relates largely to the role of lipids and essential fatty acids. She has over 170 peer-reviewed publications and has been continuously funded by the Canadian Institutes of Health Research (CIHR). Her research focuses on the role of dietary fat in providing essential fatty acids to support growth and development, including long-term effects on children's physical, cognitive and behavioural health. Sheila is investigating how specific fatty acids influence brain development and nerve function and the dietary intakes needed to ensure optimal development to affect our life-long susceptibility to disease.



Dr Pauline Emmett is an independent Senior Research Fellow at the Centre for Child and Adolescent Health in Bristol. She was head of Nutrition Research for the Avon Longitudinal Study of Parents and Children (ALSPAC) in Bristol. And has worked as a research nutritionist for 30 years at Bristol University. Studying Nutrition and Dietetics at London University, she worked as a hospital dietitian, moved into research and since 1993 has been working in the area of nutrition and diet in pregnancy and childhood. Her PhD involved research into childhood diet in the ALSPAC cohort. She is very experienced in the use of dietary assessment methods in children and adults and has 110 publications. Pauline is particularly interested in the way early eating habits (breastfeeding, introduction of solids, types of snack foods) may influence later dietary patterns and how these might relate to the development of obesity and other disease outcomes in later life. She lectures on the themes of infant feeding, childhood diet, childhood obesity and the role of dietary long-chain polyunsaturated fatty acids in child development.

Dr Sarah Bath is a registered dietitian and post-doctoral research fellow at the University of Surrey. She graduated from here in 2007 with a first class honours degree in Nutrition and Dietetics and, after working as a dietitian in the NHS for 18 months, she returned to the University to undertake a PhD under the supervision of Professor Margaret Rayman. She has studied an under-researched area in the UK - the iodine status of UK pregnant women and the food sources that contribute to iodine status. Through collaboration with the Avon Longitudinal Study of Parents and Children (ALSPAC), she has found that mild-to-moderate iodine deficiency in UK pregnant women is associated with adverse cognitive outcomes in the child. Sarah is passionate about translating her research into practical advice and has worked with the British Dietetic Association to produce a "Food Fact" sheet on iodine. She has recently been awarded a MRC Population Health Scientist fellowship to continue her work on iodine.



David Rex is a dietitian for Highland Council, working in Health & Social Care – Children's Services. He has a lead public health role for Food & Health in schools, nurseries and Children's Residential Units providing specialist dietetic advice for children with ASD and ADHD focusing on diet and children's mood, behaviour and learning and how to deal with the selective eating patterns, so common in children with ASD. He has been heavily involved in the development of the "High 5" Health & Wellbeing programme for Highland primary schools. David has a BSc in Chemistry and Food Science, a Diploma in Nutrition and Dietetics, and a Masters in Food Policy. With over 25 years experience starting as a 'teenage burger flipper', he went on to look at food and health from a range of different perspectives as food chemist and technical advisor in the food industry; community and hospital dietitian and food policy advisor for a Health Authority. He is an advocate for sustainable and socially just food systems, and is passionate about cooking and eating well.