Nestlé Nutrition Institute

WORKSHOP

100

Shaping the Future with Nutrition

Join us

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Contents

Foreword

This year marks an historical milestone: the 100th Nestlé Nutrition Institute (NNI) Workshop. As we celebrate it, we've been reflecting on Nestlé's rich history, immense dedication and tireless efforts in supporting and nurturing the nutrition science community through continuous education. This century stands as a testament to our unwavering commitment to advancing the field of nutrition and embracing continuous learning.

Starting with the publication of the first Annales Nestlé in 1942, we have been growing in credibility as a source of scientific nutrition-focused information. Along with the growth of the publication, more major milestones were achieved with the first Nestlé Nutrition Workshop, held in France in 1980. The title of that first workshop was 'Maternal Nutrition in Pregnancy: Eating for Two?', reminding us that maternal nutrition – also one of the topics covered within the 100th workshop – was already an important theme back then.

These workshops continued to be held, traveling to various regions across the world and providing better access to nutrition science knowledge in different countries. They also provided the launch pad for the iconic publication series, the NNI 'Blue Books'.

In 2004 the Nestlé Nutrition Institute was created, which then became a not-for-profit association based in Switzerland in 2010. NNI has a long-lasting commitment to unbiased, reliable nutritional science and education. Further milestones were reached as the organization embraced digital technology, launching a website in 2006 and an app in 2022. NNI stays true to its commitment of empowering healthcare providers and supporting the nutrition science community with more accessible digital innovations.

Fast forward to the 100th NNI Workshop, the overall agenda was on shaping the future with nutrition. Our speakers covered preconception to nutrition in the first stages of life up to school age.

In the first section of the workshop, our speakers looked at current understanding of the fundamentals of maternal and child nutrition. They explored how an individual's health and wellbeing are shaped by many factors, from maternal preconception nutrition to mode of birth, infant nutrition with the importance of breastfeeding and human milk research, complementary feeding practices, environmental factors and more.

The second section examined food dietary habits for optimal development. Speakers highlighted a strong evidence base for the nutritional approach that supports good health, but how in practice there are many challenges to achieving this.

During the third session, speakers discussed research into how the food system has evolved to accommodate the challenges that the global nutrition landscape is going through. This involves the shift to a more plant-based diet to account for sustainability in the diet, as well as new technological advancements to help address current and future issues that may persist.

We hope that this summary of the talks provides some food for thought on the strides we have made in nutrition for the different life stages, and the new strategies and solutions, especially in food technology, we can use to overcome the challenges of feeding the future.

Sara Colombo Mottaz,
Global Head of the Nestlé Nutrition Institute

Nestlé Nutrition Institute

Section 1: Getting the right start through maternal and child nutrition

Achievements, challenges and future direction in early life nutrition

Summary of lecture delivered by Ian Macdonald of the University of Nottingham, discussing progress and challenges in improving early nutrition

There remain significant challenges to achieving the goal of ensuring all children have access to a healthy and balanced diet. Eradicating childhood malnutrition is vital to give the next generation the best chance of optimal growth and development, and the lowest risk of developing non-communicable disease (NCD) in later life.

Nutritional recommendations can help, however, developing countries often adopt recommendations that do not suit the needs of their population. Recommended intakes are also often scaled-down versions of adult guidelines and are therefore not as evidence-based as one would wish.

> **Unbalanced nutrition during the first 1,000 days of life can have lifelong impacts.**

Nutritional deficiencies and overnutrition pose a risk to both mother and fetus. Hence, dietary intervention from the period of preconception, pregnancy and early life has the greatest potential for positive impact on the child.

Unbalanced nutrition during the first 1,000 days of life can have lifelong impacts. Deficiencies of micronutrients or calories can cause stunting and wasting, while overnutrition raises the risk of NCDs. The statistics on childhood obesity remain concerning, especially among the most economically deprived communities.

There is growing awareness of the need to provide nutrient-rich diets for children with appropriate caloric content. Excess protein in early life, particularly for children aged over 4 months and who are above the 90th percentile, increases the risk of obesity. Restricted fat in early life can result in leptin resistance and obesity in adulthood. Breast milk remains the gold standard for infant nutrition, providing both nutritive and bioactive components.

The quality of the diet of children remains important. Children's brains are relatively larger than adults, creating the need for a significant glucose supply over the course of a day. A recent study used Magnetic Resonance Imaging and Spectroscopy to measure liver glycogen in young children before and after a night's sleep and throughout the morning, investigating the impact of breakfast compared to a glass of water. Further research should establish the functional importance of adequate glycogen stores and the amounts of carbohydrate needed at breakfast.

A multiagency solution is needed to address obesity, spanning pregnancy through childhood and into young adulthood. Continued research into human milk is vital, along with support for breastfeeding mothers and improved systems for donor and banked milk. The impact of interventions on maternal nutrition should be investigated and proper nutrition advocated. Above all, children must have access to appropriately balanced, nutrient-dense diets during early life.

An offspring's health starts before conception

During her lecture, Shiao-Yng Chan, National University of Singapore, explored how at the point of conception, some elements of a child's life are already set

Early life events shape future health and wellbeing. In addition to epigenetic influences, environmental factors play a key role in determining the future health and development of the child, including risk of developing non-communicable diseases or mental health conditions.

Until recently, there has been a shortage of evidence about the impact of preconception interventions on nutrition and lifestyle. New research is beginning to demonstrate the potential of optimizing a woman's health and nutrition before conception occurs. We now need further evidence to demonstrate that preconception interventions are important, including the timings and populations that would derive clear benefit.

The NiPPeR double-blind randomized controlled trial recruited 1,729 women who were planning a pregnancy in the United Kingdom, Singapore and New Zealand. The intervention group were given a nutritional formulation containing myo-inositol, probiotics and micronutrients, where the control group took a standard micronutrient supplement.

The two groups showed no difference in risk of gestational glycaemia at 28 weeks' gestation, the primary outcome but a difference was observed for some secondary outcomes. These included risk of preterm delivery, especially associated with pre-labor rupture of membranes, operative delivery for delayed second stage and major postpartum hemorrhage.

> **As preconception can impact the health of the mother and child, the importance of early interventions should be emphasized.**

The NiPPeR study also indicated that the intervention may reduce time to conception for overweight women compared to that of normal weight women. There were also benefits for the offspring outcomes, the increase in vitamin D and zinc concentration in human milk which persisted even when supplementation stopped and reduction in the incidence of rapid weight gain and high BMI at 2 years of age.

The evidence suggests that changes in maternal health could be significant in shaping the long-term health of the child and in building resilience against non-communicable chronic diseases. Where possible, vaginal birth and breastfeeding should be encouraged and the use of antibiotics should be avoided, to help support the development of the infant microbiome.

Microbiome's life starts during birth and needs to be nurtured

Jens Walter, University College Cork explained how and when the microbiome starts being established and its role in maintaining health and development

Humans have symbiotic relationships with the communities of bacteria living within the intestinal tract. These microbiota are paramount to the host's fitness and development. Acquisition of a beneficial community of bacteria in early life is therefore crucial.

Epidemiological studies have shown that clinical and environmental factors can disrupt microbiome assembly in early life and lead to childhood and adult pathologies. These include allergic diseases, asthma, inflammatory bowel disease (IBD), obesity and diabetes.

> **Transmission of intestinal microbes at birth is thought to determine the environmental conditions that shape the microbiome of the child.**

The sterile womb hypothesis states that from a sterile uterine environment, the child acquires its gut microbiome during and after delivery. Hence, vertical transmission of intestinal microbes and horizontal transmission from environmental conditions determine the microbiome of the child.

This early life colonization has been shown to be important for microbiome assembly, therefore, disturbance of microbiome acquisition such as cesarian section and antibiotic exposure should be avoided wherever possible. Breastfeeding is also of fundamental importance in supporting the development of a healthy gut microbiome.

Recent research has helped to clarify the dynamics of early colonization and microbiome assembly, but further understanding of the mechanisms that contribute to pathologies is required. A study with gnotobiotic mice demonstrated the importance of 'priority effects' in microbiome assembly, meaning the timing of the arrival of bacterial strains influenced their own ecological success during colonization and their impact on other microbial communities.

Breast milk is of fundamental importance in supporting the development of a healthy gut microbiome. Other strategies to remedy these disruptions include vaginal seeding, fecal microbiota transplantation and probiotics. Further research is required to identify the most efficacious and safe interventions that reduce long-term risk of disease.

Understanding the ovarian clock: essential knowledge for pediatricians

Reproductive health begins at conception for baby girls, argued Huang Zhongwei, National University of Singapore

Oocytes and ovarian follicles are formed within female infants in the womb. The supply of eggs then decreases through the lifecycle, culminating in menopause and the loss of fertility. Girls born with a lower birth weight or exposed to diethylstilbestrol in the womb are at higher risk of early menopause.

The ovaries have a clock based on the hypothalamic-pituitary-ovary axis, which initiates puberty and ovarian follicle production. This mechanism is important for women's health through the impact of hormones on cardiovascular, musculoskeletal and neurocognitive health.

> **Ovarian aging is impacted by many factors, including nutrition and epigenetics.**

Early menarche is associated with higher cardiovascular risk in later life, while ovarian aging is impacted by many factors, including nutrition and epigenetics. Irregular menstrual cycle is common in the first year post-menarche, but irregular cycles after this may be a cause for concern.

Irregular menstrual cycles may be linked to anovulation or premature ovarian insufficiency and requires investigation. Conditions such as polycystic ovarian syndrome may be an underlying factor.

Reproductive organs are the first to undergo age-related decline. Oestrogen is an important hormone for women's health. Fertility declines rapidly from the age of around 37, and the probability of genetically abnormal embryos also increases from around this point.

Understanding the mechanisms of reproductive aging is important to safeguard women's health. This will help to identify novel diagnostics and therapeutics for optimal women's reproductive health.

Human milk benefit research, more to learn?

Norbert Sprenger, Nestlé Institute of Health Sciences explained how we are learning more about how HMOs in breast milk play an important role in the child's immune system

Human milk is the product of 310 million years of evolution. It originated as a glandular secretion providing moisture and antimicrobial protection for reptile eggs, eventually developing into the nutrient-rich milk produced by mammals today.

> **Studies have shown that certain HMOs are associated with protection from necrotizing enterocolitis, cow milk protein allergy, diarrhea and respiratory infections.**

WHO and UNICEF advise exclusive breastfeeding on demand for the first six months of life, continuing alongside complementary feeding to the age of two and beyond. Breastfeeding is known to support health and development of the infant and has health benefits for mothers.

Breast milk provides nutritive components including lactose, protein and fat, alongside bioactive components such as human milk oligosaccharides (HMOs), glyco-lipids, lactoferrin and osteopontin that provide support for immunity, gut health and brain development.

There are factors that may affect the HMO composition among breastfeeding women. An ongoing study of human milk composition combines 20 studies in 20 countries, with over 3,500 participants and 10,000 milk samples. The findings indicate how the composition of milk changes over time. For example, FUT2 and FUT3 genotypes vary among women and this is reflected in HMO concentration within milk.

Sialylated HMO structures also vary in human milk according to whether an infant is born preterm or at term. The HMO concentration in milk is very similar in mothers giving birth vaginally and by C-section.

HMOs also play a role in the development of the immune system, with breastfed babies having a different gut microbiome from that of formula fed babies. Studies have shown that certain HMOs are associated with protection from necrotizing enterocolitis, cow milk protein allergy, diarrhea and respiratory infections. HMO analysis also reveals associations with infant cognitive development and the interaction with *Bifidobacterium* and *Bacteroides* species. Sialylated HMOs and 3'SL are also associated with cognitive development among breastfed infants.

Further work is required to understand the interaction networks of milk components in order to guide understanding and help improve understanding of human milk and the beneficial impacts of breastmilk.

Nutrition for the sick preterm: can we make it more precise?

Josef Neu, University of Florida predicted that precision nutrition may one day be used to improve the growth and development of preterm babies

Precision nutrition has the potential to help extremely premature babies who are at risk of adverse outcomes. This approach would combine medical techniques and machine learning to optimize nutritional care.

Current techniques for nutrition of preterm infants are based on optimal nutrition for the average infant, but a personalized approach could improve the likelihood of preventing adverse outcomes such as growth failure, late onset sepsis, intestinal dysfunction and disease, and poor neurodevelopment.

> **Machine learning can analyze large datasets to create tailored feeding regimens according to infant gestational age, birth weight, growth patterns and metabolic responses.**

Mother's milk provides precision nutrition for the infant, providing a unique microbiome that varies between women. Extremely preterm babies are fed parentally and highly susceptible to infection. Machine learning can analyze large datasets to create tailored feeding regimens according to infant gestational age, birth weight, growth patterns and metabolic responses.

A digital twin may at some point be used to help predict outcomes and responses in individual infants. Continuous monitoring and adjustment of nutrition using real-time data helps healthcare providers to make informed decisions and adapt treatment to babies' needs.

Precision nutrition for premature babies could help to improve short-term outcomes as well as reducing long-term developmental risk.

Better early: Critical windows in brain and cognitive development

Bernadette Benitez, Makati Medical Center, Philippines discussed how early nutrition plays a crucial role in the cognitive development of the child

In the early years of life, children are undergoing intensive dynamic neurodevelopment that will shape their future capacity for learning, as well as physical and mental health. This is why good nutrition in early life is so important.

Exclusive breastfeeding has been associated with improved myelination at the age of two years, resulting in improved cognitive ability and development. On the other hand, nutritional deprivation or deficiency such as stunting in the child can impact brain growth and motor, cognitive and social development.

> **We need strategies to mitigate the impact of adverse events on children's development.**

The pandemic impacted rates of developmental and behavioral issues in children, with high rates of screen time and lower physical activity impacting sleep duration, speech and language ability and behavior regulation.

The COMBO study looked at the impact of maternal COVID-19 infection during pregnancy. Exposure to the infection in utero was not associated with differences in neuro-developmental scores. However, all infants born during the pandemic showed significantly lower scores on gross motor, fine motor and social skills.

Improved strategies need to be identified to screen and monitor child development to help mitigate the impact of adverse events on children's development. This should encompass nutrition from conception through childhood, provision of a safe, secure and nurturing environment and ensuring positive interactions at school, home and in the community.

Section 2: Establishing food diet habits for optimal development

Taste the difference: optimizing early life sensory exposure to develop healthy eating behavior

Marlou Lasschuijt, Wageningen University said during her lecture that it's important to expose children to different tastes and textures at developmentally appropriate points

Infants have an innate preference for sweet tastes and distaste for sour flavors. These preferences have even been demonstrated in utero by giving mothers flavored capsules and observing facial expressions of the fetus. Maternal diet can influence the taste preferences of the child, while oral anatomy and exposure to different textures can also influence food acceptance.

> **Delaying the introduction of complex textures beyond nine months of age is associated with feeding difficulties, fussiness, and reduced intake.**

Infant oral cavity doubles in size in the first years of life as the child progresses from sucking and swallowing to munching, grasping, biting and chewing. This means parents often find it challenging to know when to move from soft foods and purees on to harder food served in larger pieces.

However, delaying the introduction of complex textures beyond nine months of age is associated with feeding difficulties, fussiness, and reduced intake of family foods, fruit and vegetables. Readiness for complex textures should be judged by ability to sit upright and by developmental stage. Oral and facial muscle coordination are more important than the presence of teeth.

Children who are fed enterally during early life can experience challenges including a lack of exposure to taste and textures, negative association with feeding, and limited parent-child interaction during food. This can result in hypersensitivity to oro-pharyngeal sensory stimulation, prolonged tube feeding dependency, increased risk of aspiration and food avoidance behavior. Non-nutritive sucking, responsive feeding and hunger provocation can help address these issues.

Children who eat fast consume up to 75% more than children who eat slowly, and the rate of consumption continues over time. This can be viewed as obesogenic eating behavior leading to weight gain as more food is eaten before satiation signals are triggered.

Eating behavior is a strong trait that shapes dietary patterns. Science-based guidelines that advise on texture appropriate feeding can help to support parents and caregivers.

Strategies to develop balanced dietary habits: solving the dilemma

Eslam ElBaroudy, Cairo University, discussed the challenges of nourishing a child with feeding difficulties

Feeding difficulties are commonly encountered globally, with 13-22% of children reported as selective eaters. As children have specific dietary needs, requiring up to seven times more nutrients than adults, per kilogram of body weight, it is important to assess how feeding difficulties can impact their nutrition and health. Key nutrients needed in high quantities are energy, protein, iron, vitamin D, calcium and zinc.

> **Children with feeding difficulties may be at risk for macronutrient and micronutrient deficiencies which can result in decreased immunity and impaired cognitive development.**

What are the effects of an imbalanced diet and children's pattern of eating? Children with feeding difficulties may be at risk for macronutrient and micronutrient deficiencies which can result in decreased immunity and impaired cognitive development.

Proper introduction of complementary feeding in the infant and encouraging healthy eating practices in the child are essential. Challenges such as child acceptance of foods, and caregivers with time, knowledge and skill to prepare healthy food. Behavioral strategies include eating family meals together, avoiding distraction and providing a positive role model for children are all important parts of the solution.

Nutritional interventions also include dietary supplements and fortification of food either commercially or domestically in certain regions to combat hidden hunger as well.

Hidden hunger in 'healthy diets'

Elizabeth George Jacob, Sree Mookambika Institute of Medical Sciences, explored the concept of an intergenerational cycles of malnutrition

A malnourished child with stunting and impaired cognitive development can, in turn, become a malnourished pregnant mother giving birth to babies with low birth weight and higher risk of mortality. Hidden hunger can lead to an intergenerational cycle of malnutrition, so it is important to understand and address the nutrition of both mothers and children so as to break this cycle of malnutrition.

Maternity, including pregnancy and lactation, offers a key window of opportunity for intervention. Ensuring that mothers are well nourished can help reduce risk to them and their offspring, particularly in areas where deficiencies in key micronutrients are widespread among women of childbearing age.

> **Hidden hunger can lead to an intergenerational cycle of malnutrition, so it is important to understand and address the nutrition of both mothers and children.**

Alongside breastfeeding, age-appropriate complementary feeding is essential to support childhood nutrition. The proper and timely introduction, which includes the right quality of food is important is this can lead to growth faltering and inappropriate eating habits later in life.

Other challenges to ensure adequate nutrition in early childhood are the high nutrient needs and giving age adapted foods that can support their growth and development. Preventing micronutrient deficiencies are important as well because of its long-lasting impact such as stunting, increased vulnerability to diseases and higher mortality rate.

Supplementation, fortified foods and biofortification can help address deficiencies, alongside support for families to change their approach to food. This could include nutritional counseling, measures to ensure healthy food is available and accessible and increasing awareness. A multisectoral approach works best to improve children's nutrition.

Two sides of the same coin: strategies to address over and undernutrition

Andrew Prentice, London School of Hygiene and Tropical Medicine said nutrient-dense foods with adequate energy content help address both under- and overnutrition

Undernutrition and overnutrition are two sides of the same coin. Undernutrition causes problems like stunting, wasting, underweight and hidden hunger, whereas overnutrition leads to overweight and obesity, nutrient toxicity and metabolic syndrome. These issues affect different global regions differently, although some countries have challenges with both.

Related to this is the strong relationship between economic growth and malnutrition. As nations grow in wealth, obesity becomes more common. Very few nations achieve a balance in optimizing children's nutrition to address undernutrition without a corresponding problem in overnutrition developing.

Food quality is the key to stabilizing this pendulum, avoiding the low protein, low energy foods that cause undernutrition and the low nutrient, high energy foods that cause overnutrition. A multi-agency approach is required to change children's nutrition involving individuals, parents, healthcare professionals, the food system and the government.

The key target should be provision of food that has a balanced profile of energy and protein.

A recent UN meeting on progress in Millennium Development Goals concluded that progress on child malnutrition has stalled. The key target should be provision of food that has a balanced profile of energy and protein. Traditional infant weaning foods such as gruel are often low in both. Weaning foods that have high density of energy or protein result in a higher intake of these nutrients.

Developed countries such as the UK used to have levels of child malnutrition akin to those seen in developing countries today. Factors driving obesity include low levels of physical activity and food habits, particularly consumption of low-nutrient foods. For adults, high fat is the main driver of energy density and therefore overconsumption of calories.

For children, sugars are the main factor in the energy density of foods. However, there are a wide range of factors from sugar sweetened beverages, birth weight, mode of birth, feeding practices, maternal obesity, stress, food insecurity in the home, urban living, low income and beliefs about child preferences that may affect weight gain in children.

A move away from thinking about isolated nutrients and towards a greater focus on dietary patterns could help to deliver better outcomes for children in future.

What does healthy microbiome development look like? State of the art and beyond

The secrets of the microbiome are continuing to unfold, said to Giles Major, Nestlé Institute of Health Sciences, during his lecture

Research to date has confirmed the importance of the microbiome in early life. Recent reports have proposed a link between early appearance of certain bacteria in the first six months of life and later increased risk of immune-mediated disorders such as atopy.

The microbiota are microbes that make up the microbiome, which is the ecosystem within the gut. It has many functions including energy harvesting, production of vitamins, hormones and other metabolites, digestion, immune functions, gut transit, protection against pathogens and signaling to the brain and other organs.

There are 100 trillion symbiotic microbes and a single person can be home to over 10,000 microbial species. Each individual has a unique gut microbiota, and features that indicate health include a diverse ecosystem, presence of key species, and whether the microbiome shows resilience and produces the right metabolites.

The gut also supports immune development and self-regulation, through its metabolism. The maturation of the microbiome is dynamic and sequential, with selection pressures in early life determining the final stable composition of the microbiome in adulthood.

There are 100 trillion symbiotic microbes and a single person can be home to over 10,000 microbial species.

Full-term infants have a healthy community of *Bifidobacteria* and *Bacteroidetes* from birth, whereas preterm infants show a much more mixed and varied picture. Children born by C-section are colonized by bacteria from the hospital rather than their mother, leading to a higher level of bacteria such as *Streptococcus* and *Enterobacter*. Likewise, those who require nutrition support and are not breastfed may have delayed gut maturation.

With the crucial period of complementary feeding, dietary diversity and plant glycans have a profound impact on microbiome development and maturation. A research finding of a distinct *Bifidobacterium longum* clade and enzymes which utilize breastmilk and solid food substrates may further provide better understanding on how microbiome and immune health can be achieved.

Interventions to modulate the microbiome maturation trajectory may involve supplementation of formula with different blends of HMOs. These adjusted formulas narrow the gap in gut maturation, moving age-appropriate microbiome development closer to the pattern shown by breastfed infants.

Integrating the next-generation evidence-based medicine into clinical studies on gut microbiota modulation

Hania Szajewska, The Medical University of Warsaw described fresh takes on the role of evidence-based medicine on clinical applications of gut microbiome

It is well recognized that the practice of Evidence Based Medicine (EBM) improves healthcare decisions for patients. Research on Biotics from diet, probiotics, post biotics and symbiotics as strategies to modulate gut microbiota are ongoing. However, important questions remain about how EBM can be applied to biotics and clinical gut microbiota research. Due to this, there few recommendations on the clinical applications for children.

Key challenges include methodological issues and inconsistencies in reported outcomes, short study duration, storage and viability, lack of standardization and safety concerns. The COVID-19 pandemic was the greatest challenge to EBM we have seen for some time.

In the urgent need to find drugs in the pandemic, clinicians went ahead with medications which sounded biologically plausible but with no valid evidence. This gave rise to the need to urgently shift from conventional EBM to EBM+.

The COVID-19 pandemic was the greatest challenge to EBM we have seen for some time.

EBM+ is a new approach that systematically considers mechanistic evidence (studies which aim to explain which factors and interactions are responsible for a phenomenon) on a par with probabilistic clinical and epidemiological studies. It calls for a wider range of evidence and a more pluralistic approach such as use of real-world data like health, nutrition, biosensors, natural history data and more. Recent changes as well are the use of patient centric studies, decentralized trials, digital trials and use of artificial intelligence (AI).

Despite limitations on gut microbiota research, the role of EBM in offering recommendations for clinical practice is still of much importance. Improvements in future research and the evolving scope of EBM may prove to be of great potential in supporting clinical decision making.

Section 3: Addressing challenges to feed the future

Healthy diets at the intersection of human and planetary health

Jose Saavedra, Johns Hopkins University School of Medicine discussed how the food system impacts nature, and vice versa

In recent decades, infant mortality has reduced over 60% and stunting has fallen by over 70%. Iodine and vitamin A deficiency has dramatically decreased, but obesity and overweight has risen 20%. However, we are still not on target to meet World Health Assembly (WHA) 2030 targets for children's nutrition.

Currently, no world regions meet World Health Organization (WHO) dietary recommendations; consumption of fruit, vegetables, legumes and wholegrains are 50% below target while red meat consumption is 100% over the target. Dietary risk is second only to high systolic blood pressure as a global risk factor for mortality, while six of the other top 20 causes are diet-related.

> **We are still not on target to meet WHA 2030 targets for children's nutrition.**

The world produces enough food for everyone, but more than 50% of the global population consumes more or less energy than is healthy. We eat too much meat, dairy, high-sodium and high-sugar foods, but not enough whole grains, vegetables, legumes, fruit, nuts and seeds.

The food we eat determines health and wellness, but our choices are constrained by the choices available to us within the food chain. The food system is under pressure, with climate change and extreme weather events impacting availability, yield and nutrient content.

Food production also makes a substantial contribution of around 24% of all greenhouse gas emissions (GHG). Some foods have much higher GHG; beef produces 60 kg of emissions per kg of food, whereas nuts produce 0.3kg. Around 71% of all land is habitable. Of this, 46% is used for agriculture, with 77% supporting livestock and 23% used for crops.

The advances in our global food systems have supported a huge increase in human population, but this has had a significant impact on the environment. Healthy, sustainable and equitable diets are an important way to address the climate crisis.

Nutrition challenges and opportunities when shifting to plant-based diets

Paula Hallam, Specialist Pediatric Dietician discussed the benefits and challenges of giving plant-based diets in children

The more varied a child's diet, the more varied their diet is likely to be later in life. However, in the UK around 29% of children eat less than one portion of vegetables a day, and only 18% eat 5 portions of fruit and vegetables each day.

There is a perception that plant-based diets may be lacking in certain micronutrients, but in fact vegetarian and vegan diets can be high in micronutrients such as beta-carotene, vitamins E, C, K and B1 and B6, folate, potassium, magnesium and iron.

> **Children eating vegetarian diets have been shown to have a lower prevalence of obesity.**

Children eating vegetarian diets have been shown to have a lower prevalence of obesity, whereas high intakes of protein in infancy and childhood have been associated with increased weight gain and higher risk of later overweight and obesity. High protein intake is associated with omnivorous diets.

The growth of children on plant-based diets has been found to be similar or above that of children on omnivorous diets. A small percentage of vegan and vegetarian children who receive extended breastfeeding and delayed introduction of complementary foods are at higher risk of stunting.

Children on plant-based diets may require supplementation or dietary adjustments if they do not appear to be thriving. Common problems include not providing enough fat, or using an unfortified plant-based drink past the age of 12 months.

Omnivorous children have higher average calcium and protein intake than vegan and vegetarian children. However, all children tend to exceed recommended protein intake, which increases risk of obesity and overweight in later life.

Children should be given iron in the form of fortified cereals, legumes, tofu, edamame beans, nuts and seeds as well as enhancers such as onion, garlic and foods with beta carotene or vitamin C to aid absorption. Iron is the most common global nutrient deficiency. Although iron is often associated with meat consumption, vegan and vegetarian children typically have higher iron levels than omnivorous children.

Nut butters can be a useful way to increase a child's fat intake. Children may also be given supplements of vitamins A, D, B12, iodine, and an algal oil DHA supplement. Breastfeeding women on plant-based diets should take vitamins D and B12, iodine and DHA/EPA.

With the right approach and parent education, children on plant-based diets can be supported to ensure they achieve the right growth and development.

New food technologies addressing challenges and opportunities at food system level

In his lecture, David Kaplan, Tufts University, set out the progress made in cellular production of foods and the challenges to be overcome

Cellular production or tissue engineering can help us find alternative foods that can feed the world, are equitable, produced in healthy ways and can address the many nutritional challenges were facing.

> **The biggest challenge now is to scale up production so that it is meaningful.**

The principle is creating food without animals. The technology includes upstream, wherein cells from animals are grown in a bioreactor, then components are added to help cells grow and differentiated to muscle, fat and components of food. Downstream then leads to producing structures that are added to make structured meat or unstructured meat. Additives in this process are microbially derived alternative proteins or plant-derived materials.

Among the challenges of this technology are safety, keeping the cost reasonable, ensuring that food tastes good and is of high quality. The biggest challenge now is to scale up production so that it is meaningful.

Cellular agriculture may impact food production and create foods derived in nutritionally improved ways that are compatible with the environment. Despite the challenges, there is great potential for feeding the world in the future.

Milk proteins without cows

Julia Keppler, Wageningen University explained the process of producing milk protein in the laboratory

Through precision fermentation, it is now possible to produce laboratory grown milk proteins. The process uses acellular products such as a single cell, which is genetically modified to express genes responsible for producing milk proteins such as casein and whey. These are then cultivated in a controlled environment, with the milk proteins generated in cell factories. The milk proteins are then harvested and combined with other ingredients to create the final milk product.

> **Will this emerging technology revolutionize the future of dairy industry?**

With the laboratory grown milk proteins, there are minor structural changes, which could affect allergenicity, digestibility and functionality hence the need to test all parameters involved such as the proteins, the host and fermentation process.

Research has shown the similarities of whey protein with the cell factory proteins and the production of products such as cheese with casein. However, milk is much more complex with its components of lipids, lactose, proteins, vitamins, minerals, the probiotic effect among other others. Still, a better understanding of how milk is made could provide the potential of producing better milk in the future.

Finally, this form of research requires a multidisciplinary team encompassing safety, regulations, sustainability and more.

Moving towards the future: cell-based technology for milk production

In her lecture, Marine Kraus, Nestlé Institute of Health Sciences, explained how human milk bioactives could one day be made through cellular agriculture

Human milk is the gold standard for infant feeding and nutrition, with its bioactive components such as lactoferrin, leukocytes and human milk oligosaccharides and many more. Is it possible to reproduce these human milk bioactives in a dish? With cell-based technology, there are opportunities to produce these bioactives from mammary epithelial cells and engineered microbial cells.

In producing milk products, it is important to understand the development of the mammary gland (mammogenesis), the process of secretion of milk (lactogenesis) and the process of milk production (lactation). All these happen during different stages in female development, including puberty, pregnancy and lactation. An understanding of the different factors that can affect these processes are essential. With the multitude of functional benefits from human milk bioactives, the role of technology to produce these components looks promising.

What are the processes involved in producing the human milk bioactives? Cells are sourced from humans or cows, and mammary gland resident progenitor cells stimulate cell-based lactation for functional bioactive production. This is followed by upstream bioprocessing using an industrial-scale bioreactor. From this, a prototype is developed and finally leading to downstream bioprocessing with bioactive production, purification and formulation.

Factors to consider as well would be scalability, the cost and demonstration of the functional benefits of the products. Producing human milk components using cellular agriculture is a complex process but is promising and may bridge the gap in achieving the numerous benefits of human milk.

Conclusion

This year's workshop offers an opportunity to reflect on the progress that has been made on childhood nutrition, the challenges facing us and the strategies and solutions that can be applied. Glancing back through the 100 workshops to date, it is humbling to think how science today has built on research from the past, paving the way for change in the future.

We have a wealth of evidence about the fundamentals of early nutrition, but there are many barriers to achieving healthy nutrition for every child. Starting at preconception, through pregnancy, infancy and childhood, access to nutrients and a healthy environment shape the individual's future health.

Promotion of breastfeeding and a nutrient-dense, age-appropriated balanced diet in early years is of paramount importance. The habits and preferences that are laid down in childhood can be lifelong, with a critical window of time to ensure children's growth and development is set on the right track. Obesity, parental misconceptions of what represents a healthy diet, and access to healthy foods are all key issues.

Many of today's nutritional challenges require a multi-agency approach: obesity, for example, has complex causes and requires a holistic solution. The relationship between the food system and planetary health is another area of focus. Innovations such as cellular agriculture could help to reduce strain on natural systems. The role of the health care professional is crucial in promoting health and well-being of children.

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