COMPLEMENTARY FEEDING: Building the Foundations for a Healthy Life

87th Nestlé Nutrition Institute Workshop
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INTRODUCTION

The first 1,000 days of an infant, the time period from conception until two years of age, is the time in which the infant is the most vulnerable and which lays the foundation to its future health. The complementary feeding (CF) period from 6 to 24 months is part of the first 1,000 days during which infants undergo a huge developmental change with regards to bodily functions, personality and will. The infant’s energy needs and nutritional requirements will exceed that which breastfeeding can provide and the child is developmentally ready to receive solid foods. During this transitional period, infants also progress from exclusively milk-based liquid diet to the family diet and self-feeding. Thus, the CF period is not just an important time to satisfy an infant’s nutrition, but also a time to form healthy food preferences and feeding practices and to further stimulate the infant’s ongoing, healthy development. Inappropriate CF can lead to inhibited growth and development, unhealthy food choices and eating habits and/or result in childhood obesity, all of which have detrimental consequences for long-term health and survival of the child.

The 87th Nestlé Nutrition Institute Workshop, recently held from 8 to 11 May 2016 in Singapore, was titled “Complementary Feeding: Building The Foundations For A Healthy Life” and was a scientific platform for key stakeholders to discuss, engage and debate about the latest cutting-edge research surrounding the transitional CF period.

SESSION I
Update on Introduction of Complementary Feeding: When & What

Chairperson: Maria Makrides

In the first session, key opinion leaders presented on complementary feeding and addressed its role in healthy growth and development focusing on the timing and type of solid food introduction.

MARIA MAKRIDES (Women and Children’s Hospital, South Australian Health and Medical Research Institute, Australia) began the workshop with a presentation highlighting the differences between complementary feeding guidelines and the actual practices around the world. Guidelines from different countries have many consistent and important themes, including complementary foods at/or around 6 months of age, continued breast feeding, nutrient dense complementary foods, hygienic food practises, development of feeding skills that nurture long-term healthy eating habits and the prevention of non-communicable diseases such as obesity, allergy and coeliac disease. While relatively more data is present about the time of complementary foods introduction compared with the type of foods toddlers are eating in the second year of life, both of these vary between countries. Although coherence with guidelines is difficult to systematically access, a discrepancy is apparent as intakes for fostering long-term healthy eating habits are often suboptimal. Reflecting this trend, the 2008 Feeding Infants and Toddlers Study (FITS) found that amongst 21 to 23 months old toddlers almost a third consume candy, almost a quarter consume salty snacks and almost a fifth consume french fries or fried potato at least once a day.

“The complementary feeding period is a very essential time of an infant’s life as the nutritional requirements change and new developmental skills and healthy eating patterns and behaviours are established. Thus, optimal complementary feeding will help it to grow, develop and be free of disease.”

– Maria Makrides –
JACQUELINE GOULD (Child Nutrition Research Centre, South Australian Health and Medical Research Institute, Australia) presented on the research evidence for improving developmental outcomes in children through micronutrients during the CF period. During the first 6 to 24 months, an infant's brain grows from 25% to 80% of its adult size and specialised functional abilities develop as the brain undergoes intense phases of rapid myelination and synaptogenesis. Key nutrients for these brain developmental processes include iron, fatty acids and protein, and nutrient deficiencies have been linked to impairments or delays in motor and cognitive development. Yet, intervention studies using food, individual nutrients or multiple micronutrients in infants and children with nutrient insufficiencies or poor growth are not conclusive with only few positive outcomes reported in some studies. Inconsistent study designs of nutritional interventions during the CF period may account for mixed results found in the current literature. In most studies, child developmental outcomes were not the primary outcomes and thus, many trials did not assess the development of cognitive or motor abilities which may be a major limiting factor. Given the importance of nutrition adequacy during the first 6 to 24 months for both early infant development and long-term outcomes, more high-quality intervention studies are needed in the CF period.

“The first 6 to 24 months is a critical period for the infant's brain development as it undergoes rapid growth and functional abilities emerge. If it does not have the right micronutrients at the right time, it does not develop.”
– Jacqueline Gould –

DEBBIE PALMER (School of Paediatrics and Child Health, University of Western Australia, Australia) expanded on the topic of complementary food appropriateness and discussed ‘more allergenic’ foods such as egg and peanuts and when it is best to introduce them to the child’s diet. Recent randomized controlled trials investigated whether the timing of introduction of specific food allergens into the infant diet is critical in reducing the risk of developing a food allergy and the results suggest that avoiding allergenic foods especially beyond one year of age is not beneficial. The Enquiring About Tolerance (EAT) study compared infants who were exclusively breastfed with those whose diet included a sequential introduction of cow’s milk protein, egg, peanut, fish, sesame and wheat from 3 months of age, and no differences in food allergy outcomes were found. The Learning Early About Peanut Allergy (LEAP) trial demonstrated that the introduction of peanuts as part of a regular diet in children between 4 to 11 months significantly lowered the incidence of peanut allergy compared with children who avoided peanuts until the age of 5 years (1.9% vs 13.7%, respectively). The Solids Timing for Allergy Reduction (STAR) trial evaluated the development of egg allergy in infants who were introduced to egg from 4 months compared with those avoiding eggs between the age of 4 to 8 months. At 12 months of age, less infants with regular egg ingestion (33%) had developed an egg allergy compared to those with the egg-free diet (51%); however, the results were not statistically significant. The results of the trials suggest that there is no reason for a delay in the introduction of ‘more allergenic foods’ into the infant’s diet.

“The belief that delaying ‘more allergenic foods’ beyond 1 year of age decreases the risk of allergenic reactions has been proven incorrect.”
– Debbie Palmer –

ERIN ROSS (School of Medicine, University of Colorado Denver, USA) ended the first day of the meeting with a presentation on flavour and taste development in the first year of a child’s life. While some flavour preferences appear to be innate, they can also be learned through exposure of flavoured foods and the first experiences begin already in the uterine environment. Flavour preference also impacts novel foods acceptance, and infants and young children may require multiple exposures before a food is accepted into their repertoire. As breastfed infants experience a greater
variety of flavours through the mother’s diet compared to formula-fed infants, they appear to be more accepting of novel foods. Since the number and variety of food experiences seem to be predictors of taste acceptance, flavour exposure can be used as intervention to increase the acceptance of novel foods. However, appropriate parenting styles and feeding practices have to be set in place for a successful intervention. While parents may use appropriate behaviours with a ‘less picky’ child, they may resort to restrictive and/or ineffective strategies with ‘pickier’ children (Figure 1). Strategies need to be identified that help parents develop appropriate feeding practices for ‘picky’ children to achieve repeated taste exposures and ultimately novel food acceptance.

“When transitioning to complementary feeding, giving children a variety of foods can help them accept new foods and learn to eat foods with a variety of flavours.”

– Erin Ross –

SESSION 2

Complementary Feeding Interventions in LMIC

Chairperson: Robert Black

In the second session, the speakers examined the determinants of growth restriction and discussed interventions to improve CF and growth in infants and children in low- and middle-income countries (LMICs).

ROBERT BLACK (Bloomberg School of Public Health, John Hopkins University, USA) began the workshop with a presentation highlighting the patterns and determinants of child growth in LMICs. The deviations in growth in both weight and height are greatest in the first 2 years of life in children in LMICs showing a steep decline in height-for-age that is nearly two standard deviations below the international standard by 24 months of age. This decline is greatest for children in South Asia and sub-Saharan Africa and it has serious consequences for child mortality, development, adult stature and health. Determinants of these patterns of growth faltering include maternal factors (including age, height and short birth intervals), pregnancy and birth conditions such as infections, and dietary factors. These factors contribute to fetal growth restriction which put many infants on a lower growth trajectory. Global estimates suggest that 25% of stunting can be attributed to fetal growth restriction and even more in countries in South Asia with a high prevalence of low birth weight. Infectious diseases may contribute a similar amount and subclinical enteric infections can result in intestinal dysfunction with adverse effects on nutrition and growth. Dietary factors are important especially during the critical period of infancy as poor quality of complementary foods plays a vital role in growth faltering, while it can be prevented with dietary adequacy, e.g. diet quality may mitigate the negative effects of diarrhoea on growth.

“Determinants of infant growth restriction include maternal factors, pregnancy and birth conditions, and dietary factors.”

– Robert Black –

MARIE RUEL (Health and Nutrition Division, International Food Policy Research Institute, USA) presented on the theme of public health nutrition and spoke of indicators for assessing infant and young child feeding (IYCF) practices (World Health Organization 2008). These simple and practical indicators have been used extensively for population-level assessments, country comparisons, to track progress, for evaluating the impact of programmes aimed at improving CF practices, and for studying determinants and consequences of poor CF practices for child growth and development outcomes. Five out of ten indicators focus on CF practices that measure key dimensions of CF practices, including the timing of complementary foods introduction, dietary diversity, meal frequency and intake of iron-rich foods. Although, this set of indicators has been an invaluable tool for measuring,
documenting and advocating for faster progress in improving these practices in LMICs, limits have been identified such as the lack of validation against gold standards, the tendency for recall errors, bias, measurement errors and misclassification as well as the nature to only capture short-term CF practices. Future efforts have to be made to revise and improve the current set of indicators in order to capture the intricacies and complexities of the multiple dimensions of CF practices, and to describe usual practices at different ages. The current set of indicators for assessing YICF practices have to be revised to capture the intricacies and complexities of CF practices, and to describe usual practices at different ages.

“Five World Health Organization indicators for assessing infant and young child feeding practices measure key dimensions of complementary feeding practices, including the timing of complementary foods introduction, dietary diversity, meal frequency and intake of iron-rich foods.”
– Marie Ruel –

REBECCA HEIDKAMP (Bloomberg School of Public Health, John Hopkins University, USA) gave a presentation on the effects of CF interventions that aim to prevent growth deficits of children 6 to 23 months of age in LMICs. In the 2008 and 2013 Lancet Nutrition series, interventions to improve complementary feeding of children 6 to 23 months through caregiver education and/or provision of food supplements were cited among ten effective nutrition interventions. It was found that these interventions could potentially reduce stunting by 20% and deaths of under 5 years old children by 15% globally, if implemented together at scale in high-burden countries. The current state of the evidence for the impact of two categories of interventions, nutrition education alone and provision of nutrient rich food or nutrient supplements with or without education, on linear and ponderal growth of children 6-23 months in LMIC was reviewed. The evidence suggests that provision of food or nutrient supplements with or without education versus nutrition education alone has a modest but significant effect on weight and length gain of children 6 to 23 months only within certain LMIC contexts. The education-only intervention group was associated with reduced linear growth deceleration and decreased prevalence of stunting. Nevertheless, interpretation of these relatively small number of studies remains limited as inconsistencies in intervention designs and in reporting of growth outcomes exist.

“Evidence from complementary feeding interventions with provision of food or nutrient supplements with or without education versus nutrition education alone suggest a modest but significant effect on weight and length gain of children 6 to 23 months of age.”
– Rebecca Heidkamp –

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increase in height and weight. Nevertheless, interpretation of these relatively small number of studies remains limited as inconsistencies in intervention designs and in reporting of growth outcomes exist.

TAHMEED AHMED (James P. Grant School of Public Health, BRAC University, Bangladesh) presented on the effectiveness of ready-to-use complementary food (RUCF) interventions to address the burden of childhood malnutrition in LMICs. In Bangladesh, poverty, food insecurity and lack of awareness regarding appropriate child feeding practice are leading causes for childhood malnutrition. About 36% of under-five children suffer from linear growth retardation or stunting, 14% suffer from acute malnutrition while 33% are underweight. RUCF made of locally available food ingredients were developed, one rice-lentil-based and the other chickpea-based, to supply about 70% of the total energy and micronutrient requirements of children. Both RUCFs were locally accepted and the efficacy of each as well as that of a fortified blended food (wheat-soy-blend++, WSB++) and a commercial lipid-based nutritional supplement, all with nutritional counselling, were compared with nutritional counselling alone in rural Bangladesh. After one year of once daily supplementation in children 6 to 18 months it was found that the intervention was associated with reduced linear growth deceleration and decreased prevalence of stunting.

“Ready-to-use complementary foods made of locally available food ingredients are useful in improving the growth of children particularly in populations living in poverty and with food insecurity.”
– Tahmeed Ahmed –

LYNNETTE NEUFELD (Monitoring, Learning and Research, Global Alliance for Improved Nutrition) spoke of the challenges interventions face that aim at improving childhood nutrition fortification. Although there is great potential to improve the quality of complementary foods through the use of local ingredients, such interventions may face barriers in populations with limited accessibility and/or affordability of diverse nutrient-rich foods, particularly animal source foods. Fortified complementary foods and home fortification – single sachet micronutrient powders or small quantity lipid-based nutrient supplements to be added to a child’s food immediately before consumption – have been shown to be efficacious to improve the micronutrient status and some functional outcomes in children 6 to 23 months of age. Ample guidance for production safety and formulation alignment with recommended nutrient intakes exist. However, the success of such programmes and ultimately the achievement of nutritional status and functional outcomes is dependent on critical programme components such as the choice of delivery platform, availability, accessibility, acceptability, coverage, and utilization of FCFs and home fortificants by the target
SESSION 3
Factors Influencing Healthy Growth
Chairperson: Ken Ong

In the third session, experts addressed the role of CF in healthy infant growth and healthy feeding practices in high socio-economic settings to prevent childhood obesity.

KEN ONG (MRC Epidemiology Unit, University of Cambridge, UK) began the workshop with a presentation explaining the relationship between rapid growth and weight gain in infants (who crossed upwards through more than two weight centile bands) and higher risks for obesity in later childhood and adult life. Faster trajectory of childhood growth and development have detrimental consequences for long-term aging, health and survival. While the association between higher trajectory of weight gain and obesity in later childhood and adulthood is strong, it appears to be equally relevant to breastfed and formula-fed infants, small for gestational age and normal birth weight infants. In high socioeconomic settings, breastfed infants have a slower trajectory of weight gain compared to formula milk-fed infants, as the higher energy intakes from formula milk exceed the current energy recommendations for infants. In addition, genetic factors have been found to be strong determinants of susceptibility to obesity. These genes act in the central nervous system to regulate intrinsic levels of infant hunger and satiety, and ultimately impact the infant’s appetite and dietary behaviour. The resulting high growth trajectories may not be immediately obvious as infants may rapidly gain in weight, length, fat mass and lean mass even before the subsequent emergence of increased body mass index (BMI) and adiposity. Future efforts should be made to better understand the determinants of infant growth trajectory to develop preventive strategies against childhood obesity and its consequences in later life.

“Parents need to be educated that a lower trajectory of weight gain is optimal and we need to support them to develop techniques to cope with babies that are perceived to be hungrier.”
– Ken Ong –

MAUREEN BLACK (School of Medicine, RTI International University of Maryland, USA) spoke of responsive feeding during CF as a reciprocal interaction between parents and infants and which is particularly important for a successful progression from exclusively milk-based liquid diet to the family diet and self-feeding. This communication is important for the emotional bonding between parents and infants and helps preventing feeding problems such as food refusal, food pickiness, or disruptive mealtime behaviour. Feeding problems are very common as they occur among up to 50% population. To increase programme coverage and product utilization, it is also critical to understand the local context and culture and to take these into account when designing and implementing programmes that include behaviour change interventions. Thus, formative research is essential to help guide the design of all programmes to ultimately increase effective implementation to improve child nutrition.

“Programmes with behaviour change interventions need to take the local context and the culture of the target population into account.”
– Lynnette Neufeld –

JUNSHENG HUO (Institute of Nutrition and Health China, China DCD, China) continued with the topic of complementary food supplements and presented on a Chinese large-scale intervention programme that aims at improving childhood nutrition using a soy bean powder-based complementary food supplement called “Ying Yang Bao (YYB)”. To date, YYB has been used for a total of more than 4 million infants in 341 poor counties in rural China. In the “Infants Nutrition Intervention Project in Wenchuan Earthquake Region” project from 2008 to 2011, YYB was found to significantly improve weight-for-age Z-scores (WAZ) and weight-for-age Z-scores (WHZ) and decrease the prevalence of anemia in 6 to 24 month old infants after 18 months of YYB intervention. Since then, a total of 15 national or regional intervention projects have been carried out in rural China and a systematic review from 9 intervention studies found that YYB significantly increased haemoglobin levels, reduced the prevalence of anaemia and increased WHZ scores in children, while WAZ and height-for-age Z-scores were unaffected. Due to these benefits, an extended coverage to a total of 834 Chinese counties is planned.

“Nutrition intervention in early life provides an opportunity for an improvement in the overall well-being.”
– Junsheng Huo –
of typically developing infants and young children, and they can lead to weight-related problems, nutrition-related health conditions, and long-term behavioural problems when associated with family stress. Responsive feeding positively influences the feeding behaviour of children by stimulating children's attentiveness and interest in feeding, letting them pay attention to their internal cues of hunger and satiety, and by promoting the ability to effectively communicate their needs to their parents, all of which will lead to a successful progression to independent self-feeding. Responsive feeding also emphasizes the interactive nature of feeding as parents set guidelines within the context of eating (for example they decide what, when and where to eat), while they are required to respond to the signals given by children in an appropriate manner and in doing so, acknowledge children's feelings and allow them to decide how much they eat.

"A successful strategy to change parents’ behaviours or parenting styles is to align the messages with their concerns and beliefs regarding their children.”
– Maureen Black –

LYNNE DANIELS (School Exercise and Nutrition Sciences, Queensland University of Technology, Australia) discussed the effects of intervention studies with CF practices relevant to food preference and eating behaviours and patterns (the 'how') on longer-term outcomes in the excess food environment of affluent countries. Longer-term outcomes include growth outcomes, taste preference, food acceptance and texture tolerance. In the NOURISH trial, the intervention was to promote early feeding practices that emphasized healthy growth and eating behaviour through maternal guidance to foster long-term healthy food preferences and intake in young children from affluent socio-economic backgrounds. Overall, there were only minimal, but significant effects on dietary intake and preference. Data of this trial show that intervention targeted at the ‘when, what and how’ of early CF practices resulted in improved maternal self-reported protective feeding practices. Mothers reported a less frequent application of nonresponsive feeding practices (6 out of 9 subscales) and a more appropriate response to food refusal (7 out of 12 subscales). The effect of intervention on longitudinal outcomes in children was less pronounced. Children from the intervention group were more likely to display satiety responsiveness. There was no significant change in the BMI Z-scores of children, however, meta-analysis of individual data from four feeding trials, including NOURISH, found a significant intervention effect on BMI Z-scores at 2 years of age.

"Mothers need clear and consistent advice on continuing breastfeeding for as long as possible, and on introducing solids in a way that promotes increased acceptance of a wide range of foods and textures.”
– Lynne Daniels –

ANNE DATTILO (Nutrition Science Nestlé Infant Nutrition, USA) expanded on the topic of childhood obesity and presented on modifiable risk factors associated with healthy growth as well as interventions addressing those associated with obesity prevention during the first 1,000 days (Figure 2). Childhood obesity is a strong predictor of adult obesity and evidence from systematic reviews and meta-analyses suggest significant correlations between early childhood overweight, obesity, or measures of adiposity and modifiable factors during in utero development and early childhood. As such, cigarette smoke, excess gestational weight gain, and maternal pre-conception weight and gestational diabetes count to the in

**FIGURE 2. Modifiable risk factors associated with obesity prevention during the first 1,000 days of an infant's life.**

<table>
<thead>
<tr>
<th>Food and diet related</th>
<th>Feeding behaviour related</th>
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<tbody>
<tr>
<td>Consume a nutrient dense diet during pregnancy and lactation</td>
<td>Optimize maternal health and lifestyle in preparation for pregnancy</td>
</tr>
<tr>
<td>Adjust energy intake/expenditure to achieve recommended weight gain during pregnancy</td>
<td>Provide breast milk</td>
</tr>
<tr>
<td>Provide nutritious complementary foods and beverages at the appropriate developmental stage</td>
<td>Utilize responsive feeding practices</td>
</tr>
<tr>
<td>Exclude sugar sweetened beverages for infants and limit for toddlers</td>
<td>Foster healthy eating behaviours through shared family meals and mealtime routine</td>
</tr>
<tr>
<td>Limit TV and screen time</td>
<td>Provide opportunities for physical activity</td>
</tr>
<tr>
<td>Ensure that the infant and toddler has adequate sleep</td>
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utero modifiable factors. After birth, breastfeeding has been reported to be protective of rapid weight gain, a strong and consistent risk factor for childhood overweight. Introductory age to complementary foods, along with the quality and quantity of the diet has also been associated with infant and young children's weight status. Modifiable factors that are not directly food and diet related include parental feeding practices, maternal modeling of healthy food choices, and routines such as sleep, activity and sedentary behaviours. Recent advances in our understanding of modifiable factors associated with healthy growth during infancy have led to the first few multicomponent intervention trials targeted at obesity prevention during the first 1,000 days and so far, seven have demonstrated encouraging outcomes. Whether these interventions render sustainable results has yet to be shown.

“Understanding the modifiable factors associated with healthy growth during infancy provides an opportunity for design and assessment of interventions targeted to reverse trends in childhood obesity.”

– Anne Dattilo –

CONCLUSION

The 87th Nestlé Nutrition Institute Workshop, titled “Complementary Feeding: Building The Foundations For A Healthy Life”, highlighted the complexity of CF and its role for infant growth and development, long-term health and survival. Although CF guidelines exist, the ‘what, when and how’ of CF vary between countries and infant’s nutrient intakes are often suboptimal. It is especially during this transitional period, in which nutritional requirements change due to rapid growth and development, that the infant is particularly vulnerable to inappropriate CF practices. Non-CF or poor quality of complementary foods can result in malnutrition, stunting and wasting which still remains a frequent problem in LMICs. On the other hand, overnutrition through excess feeding can result in a faster trajectory of weight gain which is a common cause of obesity in childhood and later adulthood in high-socioeconomic settings. Yet, the CF period is also a window of opportunity as healthy dietary patterns established during this phase set the stage for healthy eating habits and food preferences later in life. These emerge with good parenting styles and parents need to be supported to develop appropriate CF practices that promote healthy dietary patterns in infants and children. Repeated exposure of infants and children to healthy foods should be encouraged as flavour experiences can help children learn to accept and eat new foods. Responsive feeding as a reciprocal communication between parents and children is an integral part of CF which can prevent feeding problems in children and influence their feeding behaviour. Thus, interventions aimed at improving child nutrition should not only provide nutrient-rich commercial complementary foods, appropriate fortificants or supplements, but also support parents with education about optimal nutrition and feeding practices. Finally, as such programmes face many challenges, successful implementation of CF interventions can only be warranted when the context and culture of the target population as well as the concerns and beliefs of parents is taken into account.