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RESEARCH ARTICLE

CHILD NUTRITION: A PILLAR TO DEVELOPMENT

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Adequate nutrition during infancy and early childhood is fundamental to the development of each child's full human potential. Breast feeding, the nature's way of nurturing the child, fulfils all the basic needs of child's body up to 6 months followed by complementary feeding having weaning paps. There is a necessity of proper nutrient requirements as this is the peak age for growth faltering, deficiencies of certain micronutrients, and common childhood illnesses such as diarrhoea. The immediate consequences of poor nutrition during these formative years include significant morbidity and mortality and delayed mental and motor development. Nutrition is the major intrauterine environmental factor that alters expression of the foetal genome and may have lifelong consequences. Therefore, it is essential to ensure that caregivers are provided with appropriate guidance regarding optimal feeding of infants and young children. Nutrition is therefore an issue of survival, health and development for current and succeeding generations.

Introduction

Nutrition is a fundamental necessity of child's life, health and development across the entire life span. Nutrition refers to the availability of energy and nutrients to the body's cells in relation to body requirements. Eating the right nutrients at the right time during growth increases a child's potential. It is well recognized that the period from birth to two years of age is a "critical window" for the promotion of optimal growth, health and behavioural development. A number of factors affect child nutrition, either directly or indirectly like food availability and dietary intake, breastfeeding, prevalence of infectious and parasitic diseases, access to health care, immunization against major childhood diseases, vitamin A supplementation, maternal care during pregnancy, water supply and sanitation, socioeconomic status, and health-seeking behaviour. After a child reaches 2 years of age, it is very difficult to reverse stunting that has occurred earlier (Martorell et al., 1994). The immediate consequences of poor nutrition during these formative years include significant morbidity and mortality and delayed mental and motor development. Nutrition disorders and compromised nutritional status are common among children with special health care needs. As many as 40% of infants and children with special health care needs are at nutritional risk (Lichtenwalter et al., 1993). Malnutrition among children is often caused by the synergistic effects of inadequate or improper food intake, repeated episodes of parasitic or other childhood diseases such as diarrhoea, and improper care during illness (Pelletier, 1994). Malnutrition is often cited as an important factor contributing to high morbidity and mortality among children in developing countries (Briend et al., 1998). Fig 1 depicts that how children meet their nutrition requirements when they at the stage of care.

Food pyramid

Children need to consume a certain number of serves from each food group to ensure that their nutritional requirements are being met. Essentially, energy from food and drink provides 'fuel' for the body. Energy comes from foods containing carbohydrate, fat and protein. This will not only promote appropriate weight gain and reduce the risk of diet related diseases, but also expose children to a variety of foods (Table 1). Cereal-based foods and baby foods (dietetic foods) are foodstuffs for particular nutritional uses and are intended for use by infants while

they are being weaned and by young children as a supplement to their diet and/or progressive adaptation to normal food.

Fig. 1: Four steps to meet nutritional needs of children when in care

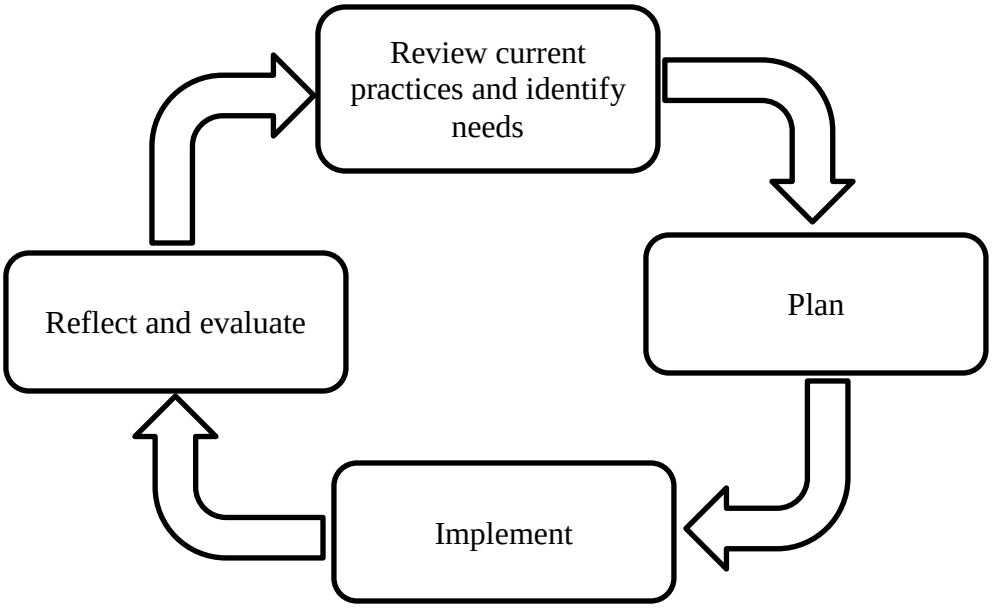


Table1: Menu Planning By Food Groups

Group1:Bread,Other Cereals and Potatoes	**Guidance for Children aged 1-5 years**	**Why?**
All types of breads, other cereals (breakfast cereal, oats/oatcakes, rice, pasta, noodles, couscous, maize meal), potato and starchy root crops (e.g. sweet potato, yam), green plantains	Every meal and most snacks should contain a portion or portions of food from this group. Early introduction to wholegrain cereal foods helps children to accept these as a regular part of their diet. Fibre-enriched cereals (i.e. breakfast cereals with added bran) should not be offered to children under 2 years.	Starchy foods provide essential energy and are an important source of many vitamins, minerals and fibre. Wholemeal bread, wholegrain cereals (e.g. wheat biscuits, porridge), pasta and brown rice should be offered to encourage children as a part of a varied diet. Young children have small stomachs and too many foods with added fibre can replace energy-rich foods needed for growth and interfere with the absorption of essential minerals such as calcium and iron.
Group 2: Fruits and Vegetables	The snack and meal combinations should provide a variety of vegetables (e.g. cucumber, tomato, carrots, celery) and fruits.	Fruit, vegetables and salads are rich sources of vitamins, minerals and other bioactive components, which protect children from ill health. provide an excellent combination of fluid and fibre and prevent constipation in young children.
Group 3: Milk and Dairy Foods	All meal and snack combinations should contain a portion or portions of food from	For infants (0-6 months) breast fed milk serves as a source for

Milk and dairy foods, yoghurts and milk-based desserts	this group.	nutrition and immunity. In children aged 1-3 milk apart from nutrition also compensates calcium level for bone & teeth development. Yoghurts can be an excellent source of calcium, protein, vitamin A and small amounts of vitamin D (whole-milk variety) and they are easy to eat.
Group 4: Meat, Fish, Eggs, Pulses, Seeds and Nuts Meat, fish and alternatives, e.g. beans, red meat (beef, pork) lentils.	Every main meal should contain a portion or portions of food from this group.	Are a major source of protein, iron and zinc.
Group 5: Foods High in Fat and Foods and Drinks High in added Sugars This group includes butter and spreads, cooking fats and oils, desserts, confectionery, cold and hot drinks, savoury snacks and bottled sauces	Within this group there are certain foods that make an important contribution to the diet of children, e.g. butter, spreads, cooking oils, fruit and milk desserts.	Butter, spreads and oils contribute to the taste, texture and enjoyment of the diet. They are important as they are concentrated sources of energy for young children who are growing rapidly. Fruit and milk desserts offer good sources ofvitamins and minerals and are a pleasant change from savoury foods.

Table 2: Human milk oligosaccharides

Micro nutrients	Human milk (g/l)	Bovine milk (g/l)
Protein	10	35
Fat	35	35
Lactose	65	45
Oligosaccharide	5-10	0.05

Table 3. Nutrient intake recommended for young children (FAO, WHO; 1988)

Age	3-6 months	6-9 months	9-12 months	1-2 years	2-3 years	3-5 years
Weight (kg)	7	8.5	9.5	11	13.5	16.5
Energy (kcal/day)	700	810	950	1150	1350	1550
Proteins (g/day)	17	20	20	20	23	36
Vitamin A (μg/day)	300	300	250	250	250	
Iron (mg/day)	7	7	7	7	7	

Infant's nutrition

Infant nutrition is the feeding behaviour of an infant during the first year after birth. Infant's nutrition has been engaging the attention of scientists and planners since long for the very simple reason that growth rate in the life of human beings is maximum during the first year of life and infant feeding practices comprising of both the breastfeeding as well as complementary feeding have major role in determining the nutritional status of the child. Poor feeding practices in infancy result in malnutrition, contributing to impaired cognitive and social development and reduced productivity in later life. Breastfeeding is an unequalled way of providing ideal food for the healthy growth and development of infants; it is also an integral part of the reproductive process with important implications for the health of mothers. As a global public health recommendation, infants should be exclusively breastfed for the

first six months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods (infant formula) while breastfeeding continues for up to 2 years of age or beyond – WHO, 2002. Complementary feeding is the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk. All infant formulas must meet the requirements of the Infant Formula Act of 1980, which establishes minimum levels for 29 nutrients and maximum levels for nine others. Formulas differ in the type of carbohydrate, protein, and fat that they contain. Lecithin, carrageenan, monoglycerides and diglycerides are added to liquid concentrate and ready-to-use formulas, acting as emulsifiers to prevent separation. Some formulas contain nucleotides which improve iron absorption, may enhance immune function, and are necessary for energy metabolism. Taurine, docosahexaenoic acid (DHA) and arachidonic acid (ARA) abundantly present in human milk is commercially added to infant formula for development of the brain, nervous system, and retina.

Nutritional superiority of breast milk

Modern science and technology has not been able to produce a better food for young infants than mother's milk. Breast feeding is the best way to satisfy the nutritional and psychological needs of the baby upto 1-6 months followed by complementary feeding with light pap along with mother's milk. Mother's milk is designed for easy digestion and assimilation. Protein, fat and calcium in mother's milk is in more soluble form which is easily digested and absorbed by the baby. The milk sugar – lactose in mother's milk provides ready energy. In addition, a part of it is converted into lactic acid in the intestines which destroy harmful bacteria present there and helps in absorption of calcium and other minerals. The amount of vitamins such as thiamine, vitamin A and vitamin C depends on the diet of the mother. Breast milk is rich in oligosaccharides and act as a source of commensal while probiotic bacteria play an important role in gut colonization and modulation of the infant gut (Coppa et al., 2004). Human milk oligosaccharides (HMOs) (fig.2) (Table 2) play a crucial role in protecting the neonates from infant diarrhoea caused due to *Campylobacter*, *Calciviruses* and other causes in the breast fed infants (Morrow et al., 2004). The prebiotic effect of HMOs promotes the growth of *Bifidobacterium bifidum* (Gyorgy et al., 1954).

Nutritional requirements

Energy requirements

Between birth and the age of 4 months the infant doubles in weight (which rises from 3.5kg to 7kg). This requires a high energy input. At 4 months, the baby's calorie requirements are estimated at 700 kcal/day. At that age an infant takes about 800ml of breast milk per day in 5-6 feeds (its stomach size limits the volume at each feed). These 800ml of milk provide about 560kcal. Hence the need to give a child a supplement of 140 kcal each day is the role of the weaning pap.

Protein requirements

The quantity of protein required is about 20g/day between 6 months and 3 years. As an indication, the mother who gives 800ml of milk provides her child with just 8g of protein a day. The weaning pap thus has to supply the child with the missing 12g of protein. Ideally, the amino acid composition of these supplementary proteins should be identical to that of breast milk. Because of its amino acid composition, *Spirulina* is also an excellent source of protein for a child: a mixture of *Spirulina* and cereal flour provides a combination of essential amino acids that is very digestible, readily assimilated and well adapted to the young child's requirements.

Vitamin requirements

Among the 12 vitamins necessary for the child's development, some are particularly indispensable at this young age.

- Vitamin A, which protects against infections and safeguards the integrity of the skin and mucous membranes and is important in sight
- Vitamin D, which fosters bone growth and protects against rickets.
- Vitamin C, which protects against scurvy
- Vitamins in group B –B1 (200–300 mg/d), B2(164–343 mg/100 kcal) (FNB, 1998), B6 (10–45 mg/100 kcal) (Picciano, 1995) and PP – which help in the utilization of the energy contained in foods
- Folates (50–65 mg/d) and Vitamin B_{12}(0.3–0.5 mg/d) (FNB, 1998), which have a role in the production of red cells

Mineral requirement

Among the numerous minerals (Table 3) essential for child development are calcium (50–140 mg/100 kcal), fluorine (<60 mg/100 kcal), zinc (maximum level of 1.5 mg/100 kcal), selenium (5 to 30 mg/d), iodine (35 to 130 mg/d) etc. Deficiency of iron is particularly widespread in the world. From birth to the age of 6 months, the child's iron requirements are supplied by breast milk, which provides iron in a well absorbed form. After 6 months it becomes difficult for the child to obtain the quantities of iron for the production of its haemoglobin in a typical developing country diet, which is why so many of them are anaemic. *Spirulina* can be a valuable source of iron for the child. Another trace element that is often deficient is zinc which can cause growth retardation.

Nutrition and child development

Child is the chief victim of interplay of nutrition, socio-economic and health factors that cause malnutrition. Brain development can be restricted by even mild malnutrition but chronic under-nutrition can lead to life-long cognitive limitations and behavioural impairments (HHBD, 2005). Nutritional problems are often unnoticed until they reach a severe level. Nutritional deficiencies are particularly harmful while a woman is pregnant and during a child's first two years of life. During this period, they pose a significant threat to mothers and to children's survival, growth and development, which in turn negatively affects children's ability to learn in school, and to work and prosper as adults. Children who are undernourished, not optimally breastfed or suffering from micronutrient deficiencies have substantially lower chances of survival than children who are well nourished. Every level of under-nutrition increases the risk of a child's dying. Children suffering from severe acute malnutrition are more than nine times likely to die than children who are not undernourished. Malnutrition in children is more an interplay of female illiteracy, ignorance about nutritional needs of infants and young children and poor access to health care. Malnourished children often exhibit extreme behaviours that can be aggressive or passive, anxious or apathetic, withdrawn, or characterized by irritability (www.surgeongeneral.gov). Poor nutrition weakens the body's ability to fight off common infections leading to longer absences from school and increased medical costs. Overweight children are stigmatized by their peers and sometimes even by parents and teachers, leading to low self-esteem, negative body image and depression. This can affect their ability to socialize well with others and to feel comfortable in a classroom setting (www.frac.org). Overweight children and adolescents have an increased frequency of risk factors for heart disease, such as high cholesterol and high blood pressure, compared to children with a healthy weight. For the same reason, Type2 diabetes, previously considered an adult disease, has increased dramatically in children and adolescents (www.surgeongeneral.gov).

Relation of under-nutrition and over-nutrition with IUGR

Maternal nutrition plays a critical role in foetal growth and development. Despite advanced prenatal care for mothers and foetuses, ~5% of human infants born in the U.S. suffers from intrauterine growth retardation (IUGR) (Flynn et al., 2002). Maternal under-nutrition during gestation reduces placental and foetal growth. Under-nutrition in pregnant women may result from low intake of dietary nutrients owing to either a limited supply of food or severe nausea and vomiting known as hyperemesis gravidarum (Snell et al., 1998). Placental insufficiency results in reduced transfer of nutrients from mother to foetus, thereby leading to foetal under-nutrition and IUGR (Bell and Ehrhardt, 2002). Many overweight and obese women unknowingly enter pregnancy and continue overeating during gestation. These women usually gain more weight during the first pregnancy and accumulate more fat during subsequent pregnancies. Maternal obesity or over-nutrition before or during pregnancy may result in foetal growth restriction and increased risk of neonatal mortality and morbidity in humans (Castro and Avina, 2006). IUGR is responsible for about 50% of non-malformed stillbirths in humans (Marshall, 2002). Arginine is a common substrate for nitric oxide (NO) and polyamine syntheses via NO synthase (NOS) and ornithine decarboxylase (ODC) (Wu et al., 1998). IUGR in humans is associated with impaired whole body NO synthesis. Maternal arginine deficiency causes IUGR, increases foetal resorption and death.

Medication-nutrient interaction

Medications and nutrients are known to interact, sometimes with detrimental effects (Table 4).

Medications can affect nutritional status in the following ways:

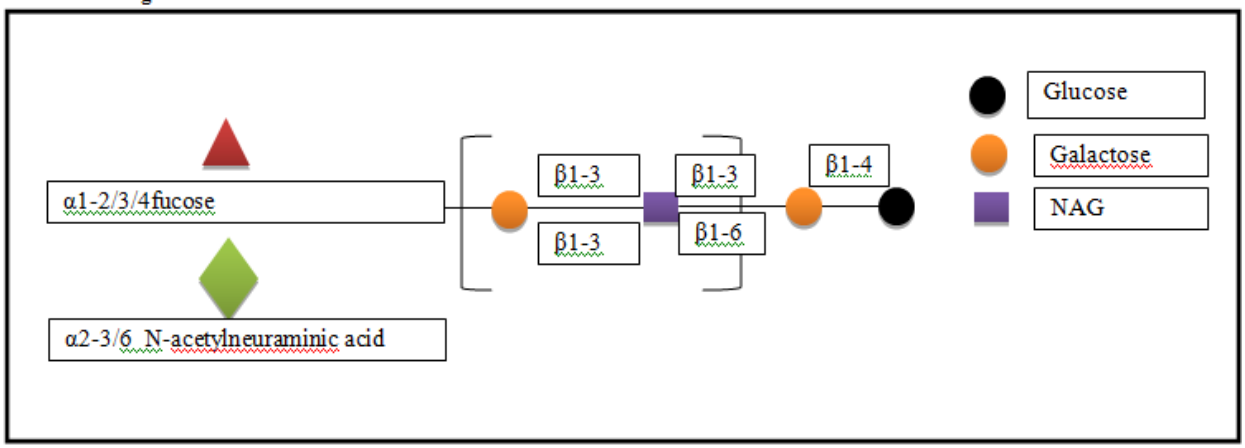
- altering the absorption, metabolism, and/or excretion of specific nutrients
- causing gastrointestinal disturbances and/or anorexia, thereby decreasing overall nutrient intake
- increasing appetite which can result in obesity
- interacting with nutrients prior to ingestion (e.g. when mixed with food or formula before administering)

Children with special health care needs are at risk for medication-nutrient interactions, especially when medications are used long-term, multiple medications are prescribed, and nutrient intake is marginal (Brizee, 2006).

Table 4.Medication-nutrient interaction

Medication	Effect
Anticonvulsants	Vitamin D, B6, B12 and folic acid deficiency
Automexetine, Methylphenidate, Dextroamphetamine	Depressed appetite in children
Diuretics (furosemide)	Anorexia and Gastrointestinal distress

Fig.2: Structure of HMO



Obesity– the cause of concern

The rapid increase in childhood obesity that has occurred over the last 30 years is considered a public health crisis. Among the US children aged 2-5 years, the prevalence of obesity has doubled. According to a recent data from the Centre forDisease Control and Prevention (CDC), approximately one in every ten preschool-aged children is obese, defined as a body mass index (BMI) greater than or equal to the sex- and age-specific 95th percentile from the 2000 CDC Growth Charts (http://www.cdc.gov/obesity/index.html). This is of great concern as childhood obesity has been associated with serious co-morbidities even among young children. This includes an increase in heart disease, type2 diabetes, asthma, sleep apnea, gallbladder disease, and psycho-social problems, including low self-esteem, depression and anxiety (Daniels, 2009). Obese children are also more likely to become obese adults and to have chronic diseases in adulthood (Ong, 2010).

Future trends

Food and good nutrition is of utmost importance to young children. Nutrition is related to five of the ten leading risks as causes of disease burden measured in DALYs (Disability Adjusted Life Years). The diet of children has drawn the attention of policy makers, not only for the impact nutritional intake has for health outcomes later in life, but also for the immediate implications for the physical health, mental health, and overall wellbeing of children. Policies must enhance nutrition program availability and accessibility in neighbourhoods. Families, schools and communities must be engaged in developing and implementing solutions for the dual problems of inadequate nutrition and obesity. Mothers should be educated about the adequate and balanced nutrition and implications of malnutrition on child's physical growth, mental health and social well-being.

Conclusion

A healthy child must have an adequate diet, rich in all the important nutrients. Healthy eating and physical activity are essential for growth and development in childhood. Even mild to moderate nutritional deficits early in life can diminish developmental achievements. So the potential health benefits of waiting until six months to introduce other foods outweigh any potential risks.

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