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Review Article

Nutrition, Brain Development and Cognition in Infants, Young Children and Elderly

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Cognitive development of infants and young children requires new stimuli in their environment for their brain to grow rapidly through neurogenesis, axonal and dendritic growth, synaptogenesis, cell death, synaptic pruning, myelination, and gliogenesis. Adequate nutrition through exclusive breast- feeding, micronutrient rich good quality complementary and age appropriate quantity of food, and intellectual stimulation throughout infancy and childhood are critical to optimal brain development and function. Genetic and environmental factors interact to provide a basis for physical growth, cognitive and socio- emotional development. Experience-dependent enriched learning in the home, school and the wider social community stimulates cognitive development and socio-emotional functioning right up to adulthood. Poor health and living in poverty and violence leads to a vicious inter-generational cycle of loss of intellectual, emotional, physical and economical potential.

Protective factors such as maternal education and food security can impact child-rearing and facilitate early stable socio-emotional development that can positively affect cognitive development and prevent infants and young children from stunting/undernutrition.

At the far the end of life cycle, the role of nutrition in preventing cognitive decline in the elderly is still unclear. There is a strong association between high homocysteine levels in blood associated with folic acid and vitamin B12 deficiency and declining cognition.

Keywords: **Nutritional Status; Brain Development; Cognition; Psychosocial Development; Environmental Factors; Micronutrients among Elderly**

Introduction

The first 1000 days of a child's life are particularly critical when vital development is occurring. The brain develops rapidly through neurogenesis, axonal and dendritic growth, synaptogenesis, cell death, synaptic pruning, myelination, and gliogenesis (Grantham-McGregor *et al*., 2007). The adult and child brain is not different and consist of the same structures and functions as also the mechanisms. Therefore, cognitive development of infants, children until adolescence requires neural enrichment or new stimuli in their environment to build on the existing structure, making it more complex through interaction and learning from the environment. "The learning environments of home, school and the wider culture therefore enable experience-dependent learning, and lay the basis for the cognitive and emotional functioning of the adult system" (Goswami, 2015). Enrichment or stimulation provided through early caring behaviours of caregivers include feeding of adequate good quality nourishing food and nutrition, verbal interactions and opportunities for learning, and protecting the child from various risks that can obstruct the normal course of development.

Genetic and environmental factors including nutrition interact and provide the basis for physical growth, cognitive and socio-emotional development. Among the multiple early environmental influences, food insecurity and resultant dietary deficiencies, inadequate and poor feeding practices, recurrent and

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chronic infections, and low levels of infant-caregiver stimulation prevent children from reaching their full potential for growth and development and also increase the risk of poor health due to reduced immunity. Continuing to live in poverty further exacerbates the consequences leading to a perpetual vicious cycle of loss of intellectual, physical and economical potential especially among infants and young children living in low and middle income countries.

Brain development during foetal and early postnatal life, is rapid, demonstrating the highest degree of plasticity. The inherent capacity to learn is present, but how and what the infant learns is modulated by the specific determinants in the environment. The genetic expression is modulated by the biological, socioeconomic as well as the psychosocial effects and the timing of these can alter the structure and function of the brain and resultant behaviour. In turn, infant behaviour directly affects the development and 'wiring' of the brain through its interactions with biological and psychosocial influences (Stiles, 2008). 'The risks associated with poverty, such as lack of stimulation or excessive stress, affect brain development, resulting in dysregulation of the hypothalamic-pituitary-adrenocortical system (Fernald and Gunnar, 2009), and change the electrical activity of the brain related to efficiency of cognitive processing'(Hackman and Farah, 2009).

This review presents current information on the impact of nutrition on brain and cognitive development in infants and young children and the elderly. Impact of factors like maternal stress and depression are also discussed since these factors are known to influence mothers' care-giving behaviour including feeding and interactions with young children.

The constraints on space prevent us from citing several early studies from India and abroad that dealt with consequences of severe protein and energy deficits on cognitive function. The recent studies quoted here are more robust in terms of study design and statistical requirements.

IUGR, Birth Weight and Cognitive Development

Intrauterine growth restriction (IUGR) and low birth weight are potential risk factors for poor cognitive development. In a study in Guatemala, birth size adjusted for gestational age was associated with infant and toddler development at 6 and 24 months of age (Kuklina *et al*., 2006). Higher birth weight (unadjusted for gestational age), was also significantly related to IQ at age 5 years (Santos *et al*., 2008) and the highest school grade achieved (Martorell *et al*., 2010).

Long-term effects of IUGR on cognition are not consistent probably because it is difficult to assess the effects of prematurity and other factors. Thus no significant difference was seen between term low birth weight (LBW) and normal birth-weight children on IQ (or parent reported behaviour at 6 years in Jamaica (Walker *et al*., 2010), or at 8 years in Brazil (Emond *et al*., 2006). However, a large study in Taiwan observed small but significant deficits in academic achievement by children at age 15 years associated with term LBW (Wang *et al*., 2008). More evidence is needed to assess long-term effects of IUGR on IQ and specific cognitive and social skills especially in low and middle income countries (Walker *et al*., 2011).

The Pune Low Birth Weight (LBW) longitudinal study from birth to adulthood in India was conducted in a cohort of 161 LBW infants with birth weights less than 2000g. The cohort divided into three groups according to their gestation –'preterm and small for gestational age' (SGA, n=61), 'full term but small for gestational age' (full term SGA, n=30) and full term control group, i.e., 'appropriate for gestational age'(AGA, n=70) was followed until age 18 years. At age 18 years, the IQ (Raven's Progressive Matrices) of the LBW groups was significantly lower than controls ($P<.002$). Preterm SGA subjects had the lowest IQ, though just within normal limits. LBW males had significantly lower IQ than male controls ($P<.03$). The IQ of pre-term SGA subjects of college educated mothers ($P<.004$) belonging to higher socio-economic class was significantly higher ($P<.04$) than those of lower social class and lesser educated mothers. The 18 year IQ was best predicted by IQ at 6 and 12 years (Chaudhari *et al*., 2013).

A South Indian study examined the effect of birth weight and head circumference on cognitive ability of 9-10 year old children. Using the Kaufman Assessment Battery, Memory and Attention-Concentration tests, results adjusted for age, sex, gestation, socio-economic status, parent's education, maternal age, parity, BMI, height, rural/urban residence, and time of testing indicated a small increase in learning ability, long-term storage and retrieval memory and visuo-spatial ability with increase in birth weight and head circumference. No significant associations were observed between birth weight/ head circumference and short-term memory, fluid reasoning, verbal IQ and attention- concentration (Sargoor *et al*., 2010).

Exclusive breast feeding soon after birth was associated with increased IQ at later ages. In a large cluster-randomised trial in Belarus, clinics assigned to breastfeeding promotion increased exclusive breastfeeding at 3 months and up to12 months with significantly higher verbal and full-scale IQ scores at 6.5 years (Kramer *et al*., 2008).

Effects of PEM on Growth, Brain and Cognitive Development

Brain development around 24 and 42 weeks of gestation is particularly vulnerable to nutritional deficiencies due to the rapid development of several neurologic processes that include synapse formation and myelination. However, being highly plastic, the developing brain can be repaired after nutrient repletion. But with severe nutrient deprivation, the plasticity of the vulnerable brain can be challenged and results in brain dysfunction that persists despite later repletion with nutrients (Georgieff, 2007).

Early severe protein-energy undernutrition leads to growth restriction, and stunting in particular has been found to affect learning and consequent poor cognitive development that may even be irreversible. Globally, 26% or about 165 million children under 5 years of age were stunted in 2011 (Özaltin, Emre *et al*., 2010). Information on stunting and education from 79 countries indicated the average prevalence of stunting to be 26·0%. 'For every 10% increase in stunting (Height for age, <-2 SD), the proportion of children reaching the final grade of primary school dropped by 7·9%'(World Health Organization 2006). The Sub-Saharan Africa and South Asia have much higher per cent stunted children compared to global figures.

Crookston *et al*. (2013) examined the associations between recovery from early stunting and cognitive abilities using longitudinal data from Ethiopia, India, Peru and Vietnam. They found that improving the growth of children who were stunted in infancy and maintaining nutrition in children who might otherwise falter may significantly benefit their schooling and cognitive achievement (Crookston *et al*., 2013). The association of early stunting with long-term poor likelihood of formal employment at age 20-22 years was observed in the Philippines (Carba *et al*., 2009) and also poorer psychological functioning in Jamaican adolescents (Walker *et al*., 2007). Therefore, the timing of growth faltering due to undernutrition appears to be important. In Guatemala, growth and development were related up to age 24 months but not from 24 to 36 months (Kuklina *et al*., 2006). Pooled data from five longitudinal studies found that a 1 SD increase in height from birth to 2 years was associated with increased schooling and inversely related to grade failures, whereas growth from 2 to 4 years had little effect indicating the importance of early nutrition below the age of 2 years (Martorell *et al*., 2010).

Chronic undernutrition can lower the energy resources of parents and children and thereby make children more apathetic and less able to attract and elicit the required attention from caregivers and parents. This leads to less attention and responsive care from parents and caregivers to support the child's growth and development (Valenzuela, (1997).

Effect of Micronutrients on Brain and Cognition

Cognitive function depends on the combined activity of billions of neurons and several biochemical pathways, and specific enzymes that require several micronutrients. Therefore in addition to macronutrients, certain micronutrients are implicated in brain functions. Iron deficiency during prenatal and neonatal periods can alter myelination, monoamine neurotransmitter synthesis, and hippocampal energy metabolism. Assessment of these effects utilize tests for speed of processing (myelination), changes in motor and emotional affect (monoamines), and recognition memory (hippocampus). Zinc deficiency affects the regulation of autonomic nervous system as well as the hippocampal and cerebellar development.

Iron deficiency anaemia can impede infant and young child's development and iron therapy may not be able to reverse its adverse effects. Preventive measures with iron supplementation to infants and their mothers during pregnancy were found to benefit children's motor, socio-emotional and language development (Lozoff *et al*., 2000).

Maternal iron deficiency anaemia at 6 to 10 weeks post-partum was found to be associated with lack of maternal sensitivity and poor infant responsiveness (Murray-Kolb and Beard, 2009) in South Africa that improved post iron treatment. At 9 months of age these infants were also delayed in their development. The prevalence of iron deficiency due to inadequate intake of iron rich foods can impair brain function (Oski, 1993).

Inadequate intake of folic acid during the first trimester of pregnancy increases the likelihood of neural tube defects (Wasserman *et al*., 1998). In some countries cereal products are fortified with folic acid to prevent this problem.

Whenever the diet offers a wide variety of foods and supplies sufficient protein and calories, it is likely that vitamin and mineral intake will also be adequate. Evidence suggests that subclinical micronutrient deficiency can disrupt psychological function in children (Nelson *et al*., 1990, Naismith *et al*., 1988).

Micronutrients have also been implicated in attention-concentration deficit hypothesis. In a matched-pair, cluster, randomization study, 6 to 15 year old residential school children in South India received a micronutrient enriched drink or a placebo drink (Vazir *et al*., 2006). The mean increment scores on the Knox Cube Test measuring attention-concentration were significantly higher among the micronutrient-enriched drink group at the end of 14 months of supplementation than the placebo drink group. Other studies tested the attention-deficit hypothesis and found that supplementation increased the time that children spent in concentrating (Benton and Cook, 1991). The study by Vazir *et al*., (2006), found no significant differences between groups on IQ or school achievement. In fact, the Full Scale, Verbal and Performance IQs of both groups were above average at baseline and no further increase was observed.

Multiple micronutrients supplementation to children with or without subclinical micronutrient deficiencies in developing countries shows inconsistent results with regard to benefits on intellectual performance. Among a group of 6 to 15-y-old schoolchildren given a multiple micronutrient supplement in doses of 50%, 100%, and 200% of the recommended dietary allowance (RDA) according to the U.S. Department of Agriculture (National Research Council, 1989), only those provided with 100% of the RDA demonstrated a significant improvement in non-verbal intelligence (Schoenthaler, 1991). There was no effect on verbal or crystallized intelligence. A selective response to non-verbal tests was predicted as they better represent biological functioning than do verbal tests that are based on incremental learning.

Children with lower dietary micronutrient intake have been reported to respond more readily to supplementation (Tofail *et al*., 2008), "responders" being children who showed increased serum micronutrient levels and improvement in mental function after supplementation.

In an earlier study, multi-vitamin deficient rural school boys randomly supplemented with B-complex vitamins or placebo for one year found higher biochemical values for riboflavin, pyridoxine and folic acid among those supplemented. However 50% of supplemented boys continued to be deficient in one or more vitamins. Psychomotor benefits of supplements were observed on arm-hand steadiness test. The study concluded that functional impact of vitamin supplements may be seen even in the absence of clear-cut clinical or biochemical change (Bamji *et al*., 1982).

Multiple Micronutrients Supplementation During Pregnancy and Infant Development

Multiple micronutrients supplementation during pregnancy shows better impact on child nutrition and development compared to supplementation with individual nutrients. Multiple micronutrients supplemented during pregnancy to Bangladeshi women and pregnant HIV-infected women in Tanzania showed small benefits to infants' motor development (Tofail *et al*., 2008, McGrath *et al*., 2006), and to infant mental development in China (Li *et al*., 2009), compared with iron and folic acid supplementation. Zinc supplementation to pregnant women in Peru had no effect on children's cognitive, social, or behavioural development at ages 4-5 years (Caulfield *et al*., 2010). Children in Nepal whose mothers received iron and folate supplementation had better IQ, motor skills and executive functioning than the placebo group at ages 7-9 years (Christian *et al*., 2010). Provision of zinc with multiple micronutrients or iron and folic acid did not have additional benefit. The inhibition of absorption of iron in the presence of zinc could be a plausible reason for the lack of benefits observed.

Efficacy trials and programmes of iodine supplementation in regions of the world where there is deficiency of iodine in soil show the significant positive effects of iodine on cognition and behaviour. Iodine deficiency also causes cretinism in extreme cases and goitre. Foods fortified with iodine such as salt, flour, are now available in developing countries to control the deficiency.

Effects of Essential Fatty Acids

Long-chain polyunsaturated fatty acids (PUFA) are involved in synaptogenesis, membrane function, and myelination. Overall, circuit-specific behavioural and neuro imaging tests are being developed for use in progressively younger infants to specifically establish the effect of such nutrient deficits accurately, both while the subject is deficient and after recovery from the deficiency (Georgieff, 2007).

Omega 3 fatty acids such as á-linolenic acid (ALNA), Docosahexaenoic acid [DHA], Eicosapentaenoic acid [EPA] are important components in myelination and synaptogenesis. Inadequate intakes of omega 3 fatty acids have been reported in pregnant women in low and middle-income countries. Trials of fish oil, DHA, or DHA and EPA supplementation in developed countries showed that infants born to supplemented mothers had improved visual acuity (Innis and Friesen, 2008), attention (Colombo *et al*., 2004) and cognitive performance (Judge *et al.,* 2007).

Infants fed docosahexaenoic acid (DHA)-enriched formula in high income countries seem to have better visual acuity with greater benefits for preterm infants. Information on essential fatty-acid [EFA] intake or the developmental effect of EFA in infants and children from low-income and middle-income countries is lacking. Brainstem auditory evoked potentials showed improvement among infants randomly assigned to receive DHA enriched formula with no comparable improvements among infants receiving regular formula feeds in Turkey (Unay *et al*., 2004). Significant improvement in motor development was observed among infants fed complementary foods fortified with micronutrients and EFA in Ghana and China (Adu-Afarwuah *et al*., 2007, Chen *et al*., 2010). More detailed research is needed to explain possible cognitive benefits of such fatty acids to infants in developing countries.

Developmental Stimulation Combined with Nutrition and Health Programmes

Stimulation occurs through appropriate responsive and increasingly complex developmental interactions (that match the child's emerging abilities) between care givers and children. Such interactions enhance the attainment of cognitive and social-emotional skills that are necessary for the later academic performance and employment success.

Inadequate stimulation because of low levels of meaningful interactions with developmentally challenging stimuli can have a negative effect on child development by disrupting basic neural circuitry. Neural disruptions are measured through stress hormones (Gunnar *et al*., 2001), brain images (Noble *et al*., 2005), and event-related potentials (Parker and Nelson, (2005).

Early stimulation can enhance neuro-cognitive processing and brain functioning and this could particularly be true for premature infants (Als *et al*., 2004). Dramatic improvements in developmental indicators due to early stimulation were seen among undernourished, institutionalized children adopted into middle-class homes. A study of undernourished Korean girls adopted into middle-class families is an excellent example of the synergistic effects of nutrition and environmental enrichment on children's intelligence (Winick *et al*., 1975). IQ scores of children adopted after 2 years of age and with a history of malnutrition scored worse than equally malnourished children adopted when they were less than 2 years old. However both groups of children had close to average IQ (Lien *et al*., 1977).

Caregiver-child interaction that provides learning opportunities and facilitates early stable socio-emotional development has been found to positively impact cognitive development. Caregiver behaviours that provide positive emotionality, involve sensitivity and responsiveness towards the child and those that avoid harsh physical and verbal punishment are critical in this context. Lack of early learning opportunities as a result of apathetic care giving contribute to loss of developmental potential.

A study in Southern India (Vazir *et al.*, 2013) found higher scores on children's cognitive development at 15 months in the intervention group that provided education to mothers on 'responsive complementary feeding and play' (RCF&PG) compared to the control group (CG) receiving standard care. The control group was similar to the second intervention group that received 'complementary feeding' (CFG) education alone. However, the overall score on the Bayley II Psychomotor Index was higher in all 3 groups compared to the Bayley II Mental Development Index (MDI). This finding is consistent with other studies (Vierhaus *et al*., 2011) suggesting that scores tend to be lower for mental than for motor items in disadvantaged populations. The finding that a stimulation intervention affects only mental, and not motor development, is fairly common (Imdad *et al*., 2011). Caregivers/mothers in the RCF&PG were shown how to use toys in more complex ways according to the developmental level of their growing child with motivational messages that these activities would help children learn skills useful for later-school achievement. Previous studies also found that developmental stimulation at a young age improved mental scores, and long-term cognitive ability despite concurrent undernutrition (Grantham-McGregor *et al*., 1991, Walker *et al*., 2004). The provision of five simple toys and instructions on how to use them in play with their infants also made it possible for mothers to implement the messages because toys were provided. However, inability to provide micronutrient-rich foods to infants was a constraint for implementing the complementary feeding messages. No improvement was observed in growth in the RCF&PG. This study demonstrated that mental development scores can be improved with very low-cost education to mothers/caregivers, even in the absence of improvements to growth. These findings have important implications for helping undernourished children from rural communities in India to start school at appropriate developmental levels for their age.

In a similar study, indigenous women in Bolivia who received information and skill building about health, hygiene, nutrition, and development in home visits that was linked to a literacy programme resulted in higher test scores for children of participant mothers compared to matched non-participants control children (Morenza *et al*., 2005).

The Integrated Child Development Scheme (ICDS) implemented by the Women and Child Development (WCD) Ministry, is India's flagship multi-packaged intervention programme to improve nutrition of marginalized children and women in the country. The ICDS provides : counselling to pregnant and lactating women about nutrition, nutrition supplements during pregnancy, monitors growth of infants and young children 0-5 years, immunizations, nutritious food supplements to children 1 to 5 years and non-formal preschool education for 3 to 6 years old children in 'Anganwadis' (preschool centres). The programme is now universal across the country and serves more than 30 million children (Rao, 2005).

A large study in India compared around 14000 ICDS children with 2000 control children from non-participating communities that had similar services. There was lesser likelihood of ICDS children being severely malnourished and greater likelihood of them attending school (Rao, 2002).

In a multi-centric study in three Southern Indian States – Andhra Pradesh, Karnataka and Tamilnadu, 3 to 5 year old preschool children (n=3724) participating in the ICDS preschool education had higher development scores using the ICMR–WHO milestones of development screening scale (Vazir *et al*., 1994) compared to matched non-participants from the same villages. In two of the three states, younger beneficiaries regardless of their nutritional status had higher development scores. The non-formal preschool education, one of the services provided by the ICDS, could have been responsible for the benefits seen (Vazir and Kashinath, 1999).

Effect of Maternal Stress, Depression, Violence and Socioeconomic Status

Maternal stress can adversely affect the brain even during the prenatal stage (Talge *et al*., 2007). The evidence among humans however, is not sufficient to establish the reversibility of the effects of stress on hypothalamic-pituitary-adrenocortical regulation (Dowd *et al*., 2007). Maternal stress found enmeshed in the poverty environment collectively affects brain development in terms of type and extent of cognitive deficits that are determined by 'the timing (sensitive periods: when environmental influences have maximum effect on brain and behavioural development during specific ages), co-occurring and cumulative influences (duration and extent of cumulative risks), and differential reactivity (moderated by infant characteristics)' (Walker *et al*., 2011). In poverty situations, risks often co-exist and also persist, exposing children to multiple and cumulative hardships during their growing years.

Maternal depression can increase the risk of low birth weight, stunting (Black *et al*., 2009), and result in insecure emotional attachment (Cooper *et al*., 2009). Because of differential reactivity, the effect of risks on behaviour might vary by individual or specific environmental characteristics including mothers' food intake and child feeding practices.

Maternal depression though widely prevalent in low and middle-income countries, is detected when efforts are made to assess it. Maternal depressive symptoms are negatively associated with early child development, stunting and poor quality of parent- child interaction across different cultures and socio economic groups (Wachs *et al*., 2009). It can occur due to several risk factors that include poverty, low education, high stress, lack of empowerment, and poor social support (Wachs *et al*., 2009). These are also the same risks associated with poor child development, suggesting a multi-level and cumulative relationship between maternal depression and loss of early child development potential.

Recent evidence from Bangladesh points to the association between infant stunting and maternal depression that can lead to unresponsive care-giving.

Child abuse and domestic violence are common in countries across the world, but community violence occurs more in low and middle income countries due to economic, class/caste and social group differences. Young children exposed to social and community violence show insecure attachments (Almqvist and Broberg, 2003), increased risk of behavioural problems (Thabet *et al*, 2006), and reduced social and increased aggressive behaviour (Kithakye *et al*., 2010). These can adversely affect cognitive development. Violence whether domestic or otherwise; causes disruptions to family structure and function. This adversely affects maternal childrearing skills.

Studies on the effective strategies to reduce stress reactions due to violence among young children were reported from Israel and Palestine (Qouta *et al*., 2008; Sadeh *et al*., 2008). Results showed that supportive parental reactions and positive family routines could reduce negative effects of exposure to violence. However, quality of parenting and the families' ability to protect young children was disrupted due to continued violence (Qouta *et al*., 2008).

Socio-economic status (SES) is composed of education, social status and wealth of families that affect their ability to purchase and consume the goods and services that are essential for health, wellbeing and identification with a particular community group. Food security or nutrition therefore mediates the effects of SES on the child's growth, development and overall well-being. Bradley and Corwyn in their review (Bradley and Corwyn, 2002) on how SES impacts on brain and mental development, emphasize the importance of the "nutrition pathway" proposed by Martorell (Martorell, 1980) 'as the process through which low SES leads to inadequate dietary intakes, nutrient deficiency and eventual morbidity and mortality'. Food insecurity and malnutrition are linked directly to nutritional deficiencies, which in turn adversely affect learning and result in developmental deficits among the most vulnerable infants and toddlers (Cook *et al*., 2008, Weinreb *et al*., 2002)**.**

The recent evidence provided in the Maternal and Child Nutrition Lancet Series (Maternal and Child Nutrition Study Group, 2013) underlines the need for a continued focus on improving nutrition and child development during the first 1000 days. Specific and focussed investments in this window-period can help prevent undernutrition including micronutrient malnutrition, overweight and obesity, loss of developmental potential and poor child development outcomes. This effort is envisaged to have long lasting effects on human capital and economic productivity. Because many women do not access nutrition-promoting services until month 5 or 6 into pregnancy, programmes need to ensure that women entering pregnancy are in a state of optimum nutrition.

Conclusions in Infants and Young Children

Global efforts have made several strides towards nutrition gains as proved by scientific research. However, the benefits achieved need to be sustained and protected from new stressors such as climate change calamities, humanitarian crises, food price volatility, violence in the current war-like scenario in parts of the world that have far reaching consequences worldwide. From the nutritional point, innovations need to be encouraged in design and delivery of nutrition-specific interventions, to make them more affordable and available. In parts of the world that are presently torn with violence, acute food shortage and difficulty in reaching children and adults trapped in far flung areas poses a major hurdle to prevent starvation deaths. The long- term consequences will need special efforts at rehabilitation. From the child development perspective, few mechanisms are in place to deal with socio-emotional effects of violence in war-like situations that can leave indelible marks on the psyche of exposed infants and young children. The long-term consequences of children facing violent horrific experiences are difficult to imagine especially among those who are left orphans with no parental buffers to mitigate the effects. Cognitive development under the circumstances is likely to be a major casualty.

Cognitive Decline in the Elderly- Role of Nutrition

While brain and cognitive development in infancy and childhood is a determinant of long- term brain function, cognitive decline due to a variety of reasons also contributes significantly to the global burden of sub optimal mental function. The causes for progressive decline in mental function in the aged could be many e.g., chronic illnesses and medication, metabolic or endocrine derangements, depression and dementia particularly in Alzheimer's (NIA-NIH Dec22, 2015). The role of nutrition is known but not well understood. Subclinical deficiency in essential nutrients (antioxidants such as vitamins C, E and beta-carotene, vitamin B12, vitamin B6, folate and nutrition-related disorders, as hypercholesterolaemia, hypertriacyl-glycerolaemia, hypertension, and diabetes could be some of the nutrition-related risk factors, which can be present for a long time before cognitive impairment becomes evident (González-Gross *et al.*, 2001). The role of B vitamins particularly folic acid and B12 and their interactions in the methylation pathways, high levels of homocysteine in circulation have all been linked to cognitive decline. However, wide differences exist in the various studies and one cannot categorically state how supplements of these vitamins would slow or delay progressive cognitive decline. Similarly, data from both the epidemiological and clinical fields indicate that the beneficial role of omega-3 (n-3) fatty acids on cognition is stronger among those with mild cognitive impairment rather than for either healthy adults or those with Alzheimer's disease. Longitudinal data seem to support the role of poor vitamin D status and increased rates of cognitive decline and increased risk of dementia. More randomised control trials (RCTs) are required to establish this fact (Bailey and Arab, 2012).

At present there is insufficient evidence to confirm a relationship between cognitive function and nutrients in the elderly. There is, however, evidence that high levels of homocysteine are associated with cognitive decline (Prince *et al.*, 2014).

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