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Early Life Nutrition Deprivation and Mental Functions

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Fetal growth

- In the USA fetal, growth velocity was **50-75 g/wk**, but during **30-38 wk** of gestation the gains become higher **150-250 g/wk**;
- In 35-40 wk fetal wt gain in **Ludhiana** was **100 gm/wk**.
- **In contrast, rural undernourished women in Varanasi, fetal wt gain was <50 gm/wk during 36-39wk.**



Brain Growth & Nutrition

- **Brain grows (IUL 6-38wk), size at birth is almost 70% of adult brain, but body wt is only 5% of an adult.**
- **During first year of life 15% brain growth occurs.** The remaining 10% of brain grows during preschool years.
 - Breast feeding/complementary feeds , micronutrients and Stimulation, play games- **Increase growth of neurons and proliferation of network of synapses, dendrites.**



Prospective study to evaluate the birth weight pattern in chronic as well as currently undernourished pregnant women. Anthropometry, hemoglobin, dietary intake, birth weight, fundal height and abdominal girth of 3700 eligible pregnant women at 16±2, 28±2 and 36±2 weeks of gestation were recorded. Outcome measure was birth weight pattern of newborns.¹

Birth weight of the babies: 7.2% <2250 g
27.4% <2500 g ;
8.2% >3000 g

Fundal height: Below 24.5 cm at 28 weeks of gestation. Did not increase during 35–39 weeks of gestation (was lower by 5 cm as compared to normal)

Maternal Weight Gain: Undernourished women in later pregnancy (during 35–43 weeks of gestation) showed weekly weight gain of 15–53 g, compared to 200-250 g/wk by healthy women.

Maternal Weight Gain: Total pregnancy weight gain was about 6 kg as compared to ideal weight gain of 13–18 kg



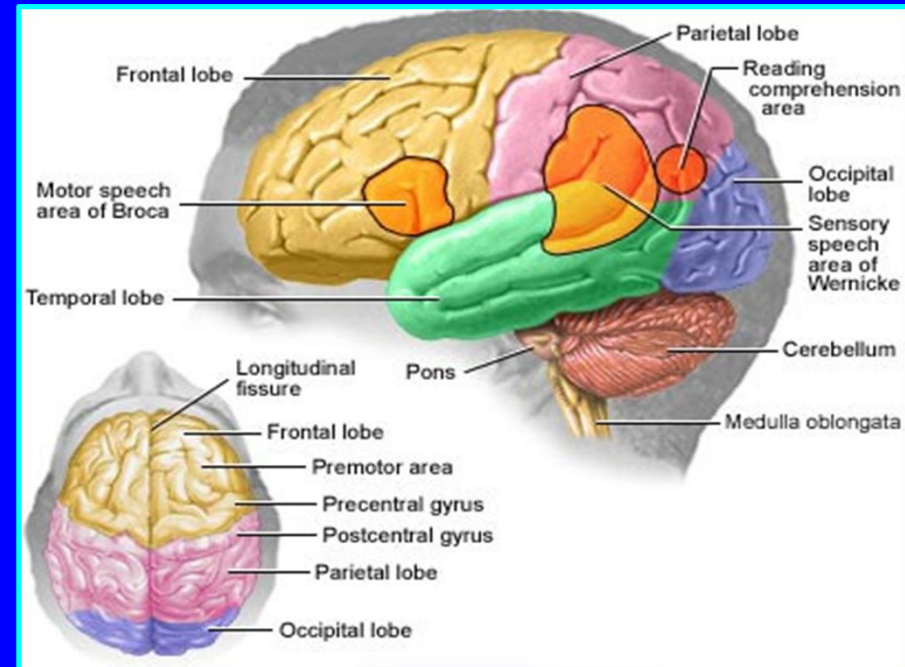
The intrauterine growth retarded offspring's of undernourished mothers

- Showed **hypotonia** in 72% and **hypoexcitability** in 56%.
- Limp posture, poor recoil of limbs, incomplete Moro's and crossed extensor responses.
- Their **EEG had shortening of sleep cycle** (REM and NREM), the reduction was marked for REM babies weighing < 2000g. There was some inter and intra hemispheric asymmetry and abnormal paroxysmal discharges; suggesting **dysmaturity of brain** (*Acta Paediatr Scand 1979 & Arch Dis Child 1980*).



Undernutrition in Early Life Affects Brain

- Poor neurobehavioral development¹ (Gesell's- 6-52 wk)
- ↓ intelligence^{1,2} (WISC 6-8 yr)
- ↓ conceptual development and motor development²



Structural changes that occur early in the course of iron deficiency may account for much of the long-term impact on decreased cognitive abilities.³

1. Kar. *et al. Behav brain Funct* 2008;4:31.

2. Upadhyay SK, Saran A, Agarwal DK, *et al.* Growth and behaviour development in rural infants in relation to malnutrition and nutrition. *IBID.* 1992;29:595–606.

3. Carlson E, Tkac I, Magid R, *et al.* Iron is essential for neuron development and memory function in mouse hippocampus. *J. Nutr.* 2009;39:4672–679.



Impact of Malnutrition on Brain Growth and Development¹⁻⁹

- Malnutrition in childhood affects IQ, cognitive function and persistence of **soft neurological signs**, impaired repetitive speed movements with higher degree of overflow and dysrhythmia with EEG changes supporting abnormalities in frontal lobe.
- The deficit in higher mental abilities and prolonged reaction time persisted in later years during adolescence
- **Brain MRI**: Both frontal lobes showed reduction in size anteriorly as well as posteriorly with loss of asymmetry

Iron folate supplementation in Pregnancy improved Birth weight(Agarwal et al IJMR 1991)

1. Agarwal KN, Das D, Agarwal DK, *et al*. Soft neurological signs and EEG pattern in rural malnourished children. *Acta Paediatr Scand*. 1989;78(6):873-878.
2. Agarwal KN, Agarwal DK, Upadhyay SK. Impact of chronic undernutrition on higher mental functions in Indian boys aged 10-12 years. *Acta Paediatr*. 1995;84(12):1357-1361.
3. Agarwal DK, Upadhyay SK, Agarwal KN. Influence of malnutrition on cognitive development assessed by Piagetian tasks. *Acta Paediatr Scand*. 1989;78(1):115-122.
4. Agarwal K, Agarwal D, Upadhyay S. Impact of chronic. *Nutr Res*. 1995;15:193-199.
5. Agarwal KN, Agarwal DK, Kumar A, *et al*. Sequelae of early undernutrition on reaction time of rural children at 11-14 years. *Indian J Med Res*. 1998;107:98-102.
6. Misra UK, Kalita J, Kumar S, *et al*. Brain MRI and cognitive evoked potentials in rural chronically undernourished children. *Nutri Res*. 1996;16:1147-1151.
7. Grantham-McGregor S. A review of studies of the effect of severe malnutrition on mental development. *J Nutr*. 1995;125:2233S-2238S.
8. Grantham-McGregor SM, Walker SP, Chang SM, *et al*. Effects of early childhood supplementation with and without stimulation on later development in stunted Jamaican children. *Am J Clin Nutr*. 1997;66(2):247-253.
9. Kar BR, Rao SL, Chandramouli BA. Cognitive development in children with chronic protein energy malnutrition. *Behav Brain Funct*. 2008;4:31.



Prospective study to evaluate the impact of Integrated Child Development Services (ICDS) program on maternal nutrition and birth weight; 28 ICDS villages and 21 non-ICDS villages in Varanasi were chosen. The study included 916 pregnant women who received nutrition supplements and 1453 who were unsupplemented. However, both groups received healthcare and nutrition education.

ICDS-supplemented mothers gained 100 g more in pregnancy.

Birth weight increased by 58 g. Preterms reduced by 12.9% and LBW births reduced by 29.4% as compared to the unsupplemented mothers.

In the unsupplemented ICDS area, preterm and LBW births reduced by 44.2% and 22.4%, respectively, as compared to non-ICDS area pregnancies.

Multiple regression analysis showed that the increased **weight gain** in pregnancy, length of **gestation, caloric intake and term hemoglobin** were significantly associated with birth weight.

Nutritional supplementation can benefit undernourished pregnant women and lead to better maternal and fetal outcomes.



Food supplementation in rural primary school children on growth and mental functions

- Primary School Children (146) received 450-500 calories with 10-12 g of protein for 172 days a year, for 2 yr (1984-1986).
- Better weight gain, No difference in Height.
- Children receiving the supplementation showed improved I Q.
- On Piagetian task conservation of liquid improved.
- The scores on arithmetic achievement test improved of 12-14 points (IJMR 1989; Agarwal et al)



Is IRON important for Brain

- Essential for **the synthesis of neurotransmitters and myelin. Deficiency – irreversible alterations.**
- The highest levels of iron found in the **basal ganglia**, though distributed throughout the brain, including the white matter.
- **Synthesis of dopamine.**
- Essential role **in myelination** and **influences dendritic growth in the hippocampus**



Adolescent Growth

- Adolescence Growth-Period extends for 3 yr.
- Ht gain is 27-29cm in boys & 24-26cm in girls;
Wt gain in both 25-30 kg.

- During this period “Cortical Bone Growth” is completed (50% of adult bone mass)**

Brain grows in the rear- **executive functioning** linked more to language learning and spatial understanding.

Myelination of the prefrontal cortex continues.

Brain adopts a “use-it-or-lose-it” pruning system, sloughing unused connections and increasing the speed of others.
30,000 synapses may be lost per second in the early adolescent.

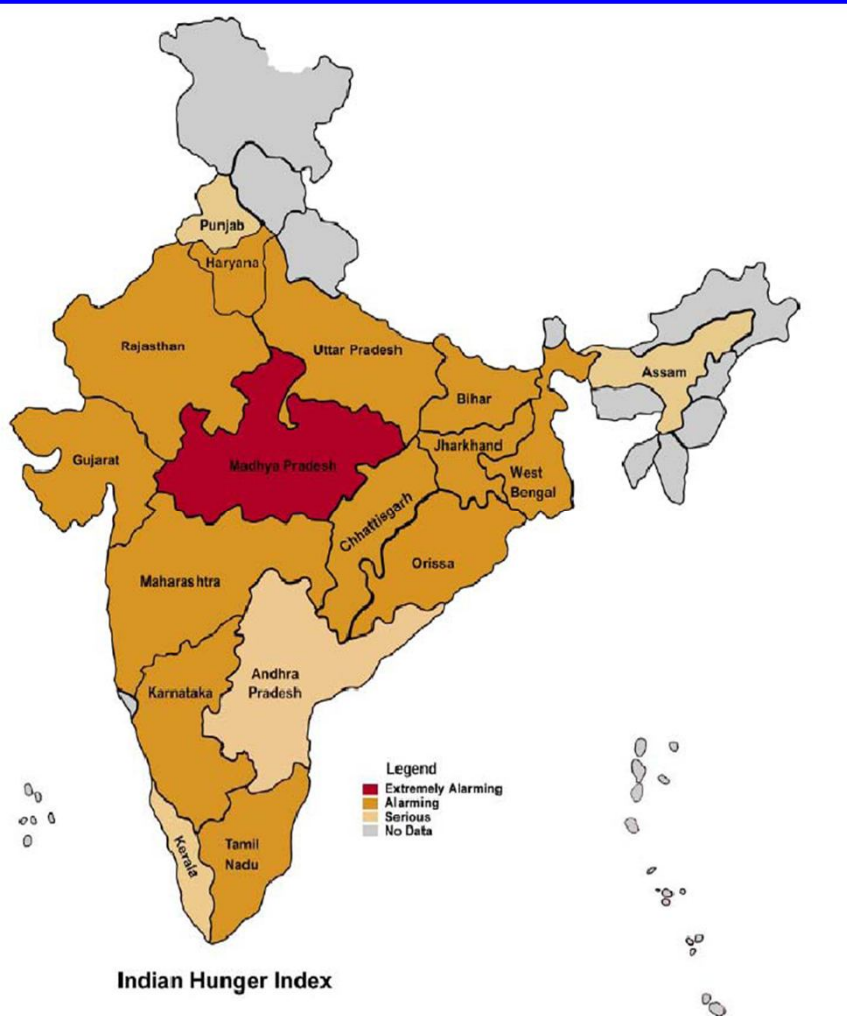


Puberty in endemic under nutrition

- ◆ Height gain was similar to affluent Indian children in adolescent growth spurt. **The deficit of early life in height was not corrected.**
 - ◆ Weight gain was 38% of the affluent Indian.
 - ◆ Undernourished-mobilized amino acids from body muscles as demonstrated by increased serum enzyme activities i.e. LDH, ALP, AST, ALT, CK,CK-MB and CK-mm.
- Boys had *delayed maturation* of: **Genitals** by 1.54 yr; **Pubic hair** by 0.82 yr and **Axillary hair** by 0.65 yr, **Testicular vol.** was similar.
 - Girls had *delayed breast development* by 2.19 yr.
 - *Menarche* was delayed by 0.82 yr.



India living in HUNGER with surplus FOOD



India is one of the major food producers in the world

The food sector contributes to about 28 % of India's GDP

In terms of world ranking India stands :

1st in the production of Cereals, Milk & Livestock population

2nd to China in producing Fruits & Vegetables

Ranks amongst the top 5 in producing Rice, Wheat, Groundnuts, Tea, Coffee, Tobacco, Spices, Sugar & Oilseeds

? Lose a million children < 5 years to malnutrition (primarily); Ranks lowest on the Global Hunger Index in South Asia (T O I, Oct 2019-World Food Day). 📢

•Adolescent Children in India-2019

213 million, take unhealthy or poor diets leading to one or the other form of **malnutrition** (UNICEF on 31st Oct 2019).

Over 80% of adolescents also suffer from the deficiency of one or more **micronutrients** such as iron, folate, zinc, vitamin A, vitamin B12 and other vitamins.

Dietary behaviours get established in **adolescence** may contribute to **nutrition**-related problems that have consequences for long-term health.

In **India**, 40 per cent of girls and 18 per cent of boys **are anaemic**.



Energy/ Protein/ Fat

- **Energy Needs**= around **136500 Kcal** as total cost of **adolescent growth spurt**. Peak energy needs 2500kcal/d, in **girls** with budding of mammary gland(SMR II-III) .In **boys**(SMR-III-IV) 3000Kcal /day.
- **Protein**=12-14% of energy- Boys 0.34g/cm ht. Girls 0.28g/cm ht.
- **Fat**=<30% of total Kcal/day.
- **Micronutrients-Vitamins** can not be assimilated without the aid of minerals. **Both are essential for growth.**



Age yr	Protein g/day	CHO g/day	Calcium mg
4-8	19	130	1000 mg (Vit D =600 IU)
Boys 9-11 Girls 9-11	34 34	130 130	1300 mg (Vit D =600 IU)
Boys 14-18 Girls 14-18 Sexual development- Boys >12 years Girls >10yr	52 46 (60g 46.0	130 130 3000 Kcal/d 2500 kcal/d	-Same-1300/600 Boys- have lean body mass 2 times of girls—need more Fe, Ca and Zn.



Adolescent girl 10-15 yr

- To provide 1/3 of daily needs -Calories1000 , protein 25 g, Ca 500mg, D3 600 IU, Fe 10mg in **school meal** with vitamins for adolescent girls. Food + vitamins
- Access for clean water, hand washing, continue Covid-19 practices. Control environmental risks - mainly pollution , poor sanitation, **STOP** sale of unhygienic food.
- Educate for Child health, immunization and education.
- Charge 5% of expenses +GST for medical facilities. School (education+meal) as society must contribute, Participation of citizens, remains essential.
- Time to **EDUCATE** for **BIRTH CONTROL** in National media. Define Family- 1 wife <2 children.
- **STOP FREE DISTRIBUTIONS- SERVICES/ FOOD.**

