



## IMPACT OF MALNUTRITION ON NEURO-DEVELOPMENT IN CHILDREN FROM A MARGINALIZED RURAL COMMUNITY IN INDIA

### Paediatrics

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### ABSTRACT

**Background:** Malnutrition and impaired early childhood development are two giant childhood health problems in the developing world and both often co-exist. Health, hygiene, immunization, psycho-motor stimulation, home environment, violence, poverty, pollution have an impact on both nutrition and neuro-development. This study tried to identify the inter-relation of mal-nutrition & neuro-developmental delay in children.

**Method:** 1536 children aged 0-5 years from a rural community were screened for nutritional status using WHO growth charts and developmental status using specific screening tools like Denver Development Screening Test II, TDSC scale and Amiel-Tyson method of tone assessment. Relevant perinatal factors were also recorded.

**Result:** 32.8% children were malnourished and 6.5% had developmental delay. In 0-3 years age group developmental delay was significantly higher among children with malnutrition (p value <0.05).

**Conclusion:** Malnutrition during 1st three years of life, is a major risk factor for poor neuro-development. Proper maternal and child nutrition, improved health & hygiene and adequate psychomotor stimulation will improve developmental outcome in children.

### KEYWORDS

Developmental delay, malnutrition

### INTRODUCTION

Early Childhood is the foundation of future life. A healthy and well-nourished child, growing to his full potential, achieving developmental milestones adequately, will eventually grow up into a healthy, balanced, well-functioning individual, ready to face life and achieve his best. Such persons will build a healthy, prospering society. Thus, to quote UNICEF, "Early childhood development is the key to a full and productive life for a child and to the progress of a nation."

Unfortunately, we are far from achieving this goal; malnutrition and impaired early childhood development continue to exist as two giant health problems in children, particularly in the developing world. Over 1 billion people worldwide are under-nourished and 1 billion live with disability<sup>1,2</sup>. Sadly, 71% of the severely wasted, 56% of the stunted and 67% of the underweight children hail from Asia<sup>3</sup>. The prevalence of child under-nutrition in India is among the highest in the world; nearly double that of sub-Saharan Africa<sup>4</sup>. A recent survey of disability in 18 low and middle income countries showed that 23% of 2-9 year old children had or were at risk for disabilities<sup>5</sup>; 80.8 million children ages 3 to 4 years in Low and Middle Income Countries experienced low cognitive and/or socio-emotional development, with the largest number of affected children in sub-Saharan Africa (29.4 million), followed by South Asia (27.7 million) and the East Asia and Pacific region (15.1 million). Positive associations were found between low development scores and stunting, poverty, male sex, rural residence, and lack of cognitive stimulation.<sup>6</sup>

Developmental delays in early childhood are estimated to affect about 10% of children in India<sup>7</sup>.

Early childhood is the period of most rapid growth and development. Starting from conception through birth, into the first five years of life the child grows in all parameters and his brain development progresses at maximum speed, attaining 90% of brain growth by 8 years of life. This early childhood development is dependent largely on nutrition. Studies from across the globe indicate that malnutrition is closely linked with developmental delay in all domains. Malnutrition in the first 1000 days of life can lead to neuro-developmental impairment. Aberrations in neurodevelopment may lead to various conditions ranging from cerebral palsy to poor cognition and global developmental delay (GDD), language and communication disorders, behavioural problems like ADHD (Attention Deficit Hyperactivity Disorder), autism spectrum disorder (ASD), learning disabilities and dyslexia.

Moreover, number of common factors including health, hygiene, immunization, psycho-motor stimulation, proper home environment,

violence, poverty, pollution etc have an impact on both nutrition and neuro-development.

In this field based study conducted in a marginalized, rural community in Eastern India, we have tried to identify the prevalence and mutual relation between malnutrition and neuro-developmental delay in children upto six years of age.

### METHODS

An observational cohort study was conducted in a marginalized rural district in India between April 2016 and March 2017. Our study population included 1536 children aged 0-60 months. The geographical area covered included 119 villages with a total population of 1,74,620.

We enrolled children attending 20 Government-run child development centres (ICDS centres) and 20 health centres for medical reason or routine health checkup. Children suffering from any chronic illness or major congenital anomaly were excluded from the study.

A structured format was used, which had information related to birth weight, relevant perinatal history, anthropometric measurements (weight, height and mid-arm circumference) and developmental assessment. Anthropometry was done using an electronic weighing scale, an infantometer (for children up to 2 yrs) and stadiometer (2 yrs and above) and measuring tape to record weight, length or height, mid-arm circumference (MAC) and head circumference. The developmental screening was done by using Denver Development Screening Test II, modified TDSC (*Trivandrum Developmental Screening Chart*) chart for 0-3 and 3-6 years and Amiel-Tyson method<sup>8,9</sup> of tone assessment. General examination, a brief neurological examination and neuro-motor assessment were conducted by the paediatrician. Nutritional status was determined by deriving the Z-score for weight for length. By using WHO growth chart for weight for length those with Z score between +2 and -2 were considered normally nourished. Those children had Z score below -2 was considered malnourished.

The incidence of different grades of malnutrition and developmental challenges were determined and the mutual relations were looked into. The data were analysed using Excel and SPSS version 17.

### RESULTS

In this study the total number of children screened was 1536, the age range being 0-60 months. The male female ratio was 756:780 (male 49.2%, Female 50.78%).

Of the children screened 228 were below 1 year of age (16.3%), 326 were between 1 and 2 years (23.4%), 280 were between 2-3 years (20.1%) and rest 557 were between 3 and 6 years of age (40.0%).

In this population 33.09% were malnourished (16.2% had severe acute malnutrition) and 6.5% had some developmental challenge.

Age-wise distribution of malnutrition (table 1)

In the study population, 100 were detected to have developmental

**Figure 1 Age-wise incidence of developmental challenge/delay**

Age group	Total no (n)	SAM (%) [wt/ht Z score <-3]	Moderate malnutrition(%) [wt/ht Z score <-2to-3]	Overall malnutrition(%) [wt/ht Z score <-2]	Normal nutrition (%) [wt/ht Z score -2 or more]
Birth upto 1 yr	227	22 (9.6)	43 (18.9)	65 (28.6)	162(71.4)
1yr upto 2yrs	326	66(20.2)	45(13.8)	111(34.0)	215(66)
2yrs upto 3 yrs	280	43(15.3)	49(17.5)	92(32.8)	188(67.2)
3yrs and above	557	93(16.6)	104(18.6)	197(35.3)	360(64.7)

We also looked into the incidence of developmental delay at different nutritional levels in the different age groups, thereby attempting to compare the impact of nutrition on neuro-development at different ages, starting from birth.

**Table 2: Developmental challenges according to birth weight**

Birth weight (in Kg)	Total no	Dev. Delay (%)
<1.5	13	3 (23)
1.5-<2	7	51 (13.7)
2-<2.5	13	212 (6.1)
2.5 and above	61	1019 (5.9)

Lower the birth weight, greater the chance of developmental delay at a later age. IUGR babies have a greater propensity for developmental delay.

In the 1<sup>st</sup> year of life 3.6% of infants with normal nutrition compared to 6.15% of malnourished children (wt for length Z score <2) showed evidence of developmental delay. In the 2<sup>nd</sup> year of life, the percentages were 7.5% and 13.4% respectively. In the 3<sup>rd</sup> year of life the values were 2.7% and 8.3%.

**Table3: Developmental Challenge according to nutritional status upto 3 years of age**

	Developmental challenge(%)	Normal development(%)	Total
Normal nutrition	27(4.8)	533(95.2)	560
Malnutrition	28(10.1)	249(89.1)	277
Total	55	782	837

P=0.0048

Incidence of developmental challenges in children with malnutrition versus normal nutrition was significantly high (p=0.0048)

Beyond three years nutritional status does not show any relation with neuro-development.

Comparing the incidence of malnutrition in developmentally challenged children, in relation to normally developing children we found that 37% of challenged children had malnutrition, with SAM in 21%, whereas only 30.9% of normally developing children showed evidence of malnutrition.

**Table 4 Malnutrition in developmentally challenged children (age wise)**

Age group	Total Normal dev	Malnutrition (%) [Z score <-2]	Total Dev delay	Malnutrition (%) [Z score <-2]
1st year	218	57 (26.1)	10	5 (50)
2nd year	293	105 (36.1)	32	16 (50)
3rd year	257	78 (30.3)	13	9 (69.2)
3-6 years	522	176 (33.7)	17	2 (11.7)

delay/ challenges, accounting for 6.5% of total population.

Out of these 100 children, cerebral palsy and motor developmental delay were seen in 31 children, global developmental delay(GDD) and mental retardation(MR) accounted for 19 cases and speech delay (SD) was found in 31 children. Mild delay in acquiring milestones was noted in 22 children. We found 1 child with Autism Spectrum Disorder (ASD), 2 with visual impairment and 2 with established hearing impairment. There were some overlaps in diagnosis, with more than one defect in a child.

**Table 5 Incidence of malnutrition in developmentally challenged children upto 3 years of age**

	Malnutrition	Normal nutrition	Total	P value
Normal Development	240 (31.2)	528 (68.8)	768	0.0009
Developmentally challenged	30 (54.5)	25 (45.5)	55	
Total	270	553	823	

The association between development and malnutrition in this age group is statistically extremely significant.

**DISCUSSION**

In our study we have looked into the incidence of malnutrition and developmental delay in the study population and have attempted to analyze their co-existence.

Occurrence of malnutrition is minimum in the 1<sup>st</sup> year of life (28.6%), while beyond 1 year the average incidence is 33.8%. Incidence of SAM is also minimum in the 1<sup>st</sup> year (9.6%), followed by a marked surge to 20.2% in the 2<sup>nd</sup> year of life, which again recedes to 15-16% from the 3<sup>rd</sup> year onwards. Breast feeding in the 1<sup>st</sup> year of life, followed by improper complementary feeds in the 2<sup>nd</sup> year is probably responsible for this phenomenon.

Developmental challenges were detected in 100 children, of which motor disability and challenges were the highest, followed by speech defects and cognitive delay. Within the 1<sup>st</sup> year mild delay and tone abnormalities are more evident, suggesting a CP in evolution. In the 2<sup>nd</sup> year incidence of cerebral palsy increased, with the advent of early speech delay. Among 2-3 year old toddlers speech delay was the major problem, while 3-6 year olds presented with cognitive delay as well as established cerebral palsy and speech delay.

In a study conducted on high-risk babies discharged from Neonatal Intensive Care Units in the same geographic area<sup>10</sup>, the prevalence of different developmental challenges were similar to the present study. Motor delay and cerebral palsy was reported to contribute to 38.5%, followed by speech delay in 26.6% and cognitive delay in 16.9%.

Studies from across the globe indicate that malnutrition is closely linked with developmental delay in all domains. The physiology of brain development offers an explanation to this direct link. Brain development starts from the 22<sup>nd</sup> day of conception with the in-folding of the neural plate and continues rapidly through-out gestation and the first two years of life, with neurogenesis, axonal and dendritic growth, synaptogenesis, programmed cell death and pruning, myelination and gliogenesis<sup>11</sup>. Various macro and micro-nutrients, which include Iron, Zinc, Iodine, Vitamins B1, B12 and Folate, Vitamins C, D, Choline and essential fatty acids play their role at the different stages of development<sup>4</sup>

The developing brain between 24-42 weeks of gestation is particularly vulnerable to nutritional insults. Human studies reveal that maternal malnutrition can result in global and specific neuro-developmental sequelae developing at different stages of life.

In our study we noted that lower the birth weight, greater the chance of

developmental delay at a later age. IUGR babies have a greater propensity for developmental delay. A similar increased occurrence of delayed development at 1 year of age was demonstrated in LBW babies showed in an Indian<sup>10</sup> and a Brazilian study<sup>12</sup>.

Though association between birth size and development at 6 and 24 months has been demonstrated, evidence of long-term effects on neuro-development are less consistent<sup>5</sup>. Protective factors after birth, as discussed below, may reduce the risk of long term effects.

Studies from across the globe have shown that children exposed to severe acute malnutrition in early life have poor cognitive function, poor school achievement and behavioural problems<sup>13-16</sup>. Low weight-for-age and height-for-age were also reported to be associated with developmental delay from studies conducted in India, Ethiopia and Bangladesh<sup>17-19</sup>. In our study in the first 3 years of life incidence of developmental delay in malnourished children is significantly higher, whereas, beyond three years nutritional status does not show any relation with neuro-development.

Developmental challenges may, in turn, perpetuate the malnourished state. The challenged child cannot compete for the family plate in a setting where food quantum is restricted, which leads to less food intake. These children tend to be neglected in the family. Moreover, recurrent infections, chronic diseases and vomiting in these vulnerable children further affect their nutrition.<sup>20</sup> This fact has been demonstrated in our study, where 37% of challenged children had malnutrition, with SAM in 21%, whereas only 30.9% of normally developing children showed evidence of malnutrition. The association between development and malnutrition was found to be extremely significant statistically with a p value of 0.0009.

Malnutrition and developmental challenges are not only affecting each other, but both problems are being aggravated by the presence of various common biological and social factors. The International Child Development Steering Group led by Susan P Walker in 2007<sup>21</sup> identified modifiable risk factors like inadequate cognitive stimulation, iodine deficiency and iron deficiency anaemia. The same authors, in 2011, have emphasised on other risk factors like Malaria, IUGR, violence and exposure to heavy metals, maternal depression, institutionalization and societal violence, with adequate research evidence<sup>7</sup> as contributing factors. All these factors can simultaneously affect a child's nutrition and development.

Susan Walker et al have further stated that 'Over 200 million children under 5 years of age in low- and middle-income countries – and increasing numbers in OECD countries and emerging economies – will face inequalities and fail to reach their full developmental potential because they grow up with a broad range of risk factors. These include, most notably, poverty; poor health, including malnutrition and infection with HIV; high levels of family and environmental stress and exposure to violence, abuse, neglect and exploitation; and inadequate care and learning opportunities'<sup>22</sup>.

Hence convergence of multiple interventions, medical, nutritional, educational and social is necessary to achieve adequate early childhood growth and development, whereby the child will reach his best, as per his potential.

## CONCLUSION

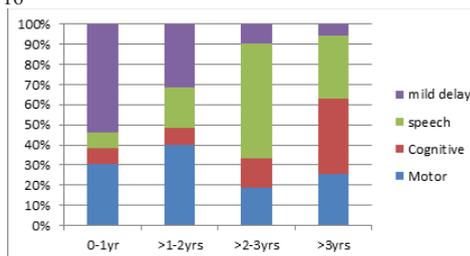
In a marginalized, under-privileged community the brunt of poverty, poor nutrition, poor hygiene, lack of health awareness, inadequate mother and child care, pollution, social instability, all fall on the growing child, impairing his growth and development, not permitting him to attain his potentiality. This can be prevented with a multi-pronged approach to provide proper nutrition to mother and child, focus on their health and hygiene and also stimulate early childhood development through adequate psychomotor stimulation and early intervention. With only a focused, convergent approach can we combat the two monstrous childhood maladies, thereby paving way to a brighter future.

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**ETHICAL CLEARANCE:** Obtained from IC City-IEC, dated 10/06/16



**Figure 1** Age-wise incidence of developmental challenge/delay

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