Brain development begins shortly after conception, proceeds at an expected rate, and continues into adulthood. During the first 1,000 days (conception to age 24 months), brain development is rapid, with nutrition playing an important role in the expression of the genetic code. Recent animal and human findings have illustrated the specificity of nutritional deficiencies on brain development, including neuron proliferation; axon and dendrite growth; synapse formation, pruning, and function; myelination; and apoptosis, depending on the timing, chronicity, and severity of the deficiencies [1]. Brain development is guided by sensitive periods that are responsive to environmental experiences in a process referred to as neural plasticity [2]. Adverse experiences, including nutritional deprivation, can undermine brain development, with negative effects on health, education as well as psychological and economic consequences that extend into later life and subsequent generations. Beneficial experiences, such as maternal nurturance and responsive care, influence the neural circuitry that underlies regulatory processes and cognition and promote positive development.

**Nutritional Threats**

In line with the sensitive periods guiding brain development, the timing, chronicity, and severity of nutritional deficiencies can have differential effects on brain development and subsequent cognitive and emotional processes. Nutritional influences on brain development begin prenatally, forcing infants onto negative trajectories prior to birth [3, 4]. Maternal undernutrition (low body mass) and iron deficiency anemia undermine fetal development, resulting in prematurity, small-for-gestational-age infants, or both. Trials of both prenatal and preconception nutritional interventions are underway, with controversial findings. For example, a recent systematic review and meta-analysis of prenatal multiple micronutrient trials [5] found inconsistent evidence regarding the
effects of multiple micronutrients compared to iron-folic acid supple-
mentation in relation to infant survival, growth, body composition, blood
pressure, respiratory functioning, or cognition, and others have reported
increased rates of asphyxia associated with prenatal multiple micronutri-
ent supplementation [6].

Nutritional deficiencies during childhood, including stunting, wast-
ing, and micronutrient deficiencies, are associated with poor develop-
mental outcomes, resulting in poor school performance, psychological
problems, and low wage earning. Nutritional interventions can have ben-
eficial effects on nutritional deficiencies, particularly when they are
introduced early in life [7]. However, the association between nutrition
interventions and children's cognitive development is less clear. For exam-
ple, even when anemia has been corrected, children may experience long-
term deficits in neurocognitive functioning [8].

Protective factors

Brain development is also influenced by positive experiences, nota-
bly nurturant and maternal interactions. Data from extreme conditions
(e.g., maltreatment and institutional rearing) have shown that although
neural development is compromised, recovery is sometimes possible
when children are exposed to responsive and stimulating experiences.
The Bucharest Early Intervention Trial, a randomized controlled trial
of institutionally reared children who were assigned to foster care or
remained in the institution, has shown both the long-term consequences
on brain development and functioning associated with early institutional
rearing and the mitigating effects of foster care, depending on the tim-
ing of the assignment. Findings are complex, as expected by the children's
varying experiences. Recent evidence has shown the beneficial associa-
tions of maternal-infant interactions on electroencephalography among
children without early adversities, suggesting that the beneficial effects of
responsive caregiving can influence brain development among typically
developing infants [9].

Evidence for early interventions based on brain development
research lead to 3 recommendations: (1) ensure nutritional adequacy
and the avoidance of other forms of early adverse experiences, (2) ensure
nurturance and responsive caregiving, and (3) initiate interventions early
in the developmental process to take advantage of the sensitive periods
of brain development when neural plasticity is high. Early findings from
integrated nutrition/responsive caregiving interventions suggest that such
interventions are feasible and effective in promoting early development.

Implementation of integrated interventions will require governance
structures that support integrated policies and programming across
sectors, along with attention to workforce training, supervision, and monitoring. Investment in early intervention based on evidence from brain development is an effective means to ensure that children have the necessary health, cognition, creativity, and commitment to achieve the Sustainable Development Goals.

**References**