ROADMAP TO IMPROVE LIVELIHOODS IN AFRICA

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CHAPTER TWENTY-FOUR

CONTRIBUTION OF ADEQUATE NUTRITION IN COGNITIVE DEVELOPMENT IN CHILDREN

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Abstract
Adequate nutrition is essential to ensure health, well-being, productivity and active life. In addition, it is a major determinant of intellectual development, yet the burden of malnutrition in its diverse forms remains high in Asia and Africa. Though many programmes exist to address this burden, some are particularly focused on the sensitive window of opportunity to give children healthy start in life. This paper attempts to summarise the contribution of adequate nutrition to cognitive development and discuss some of the programmes that are in place to reduce this burden.
The first 1000 days of life is widely considered as particularly crucial following the milestone sequential development of the various brain tissues and neurons. This period emphasises the need to promote adequate nutrition prior, during and post pregnancy. Optimal infant and young child feeding practices should be promoted. Although several nutrients are important for healthy neurodevelopment, protein, zinc, iron, folate, iodine, vitamins A, D, B_6, and B_{12}; and long-chain polyunsaturated fatty acids have specific roles at different phases of neurodevelopment. Consequently, inadequate supply of these nutrients early in life may cause life-long deficits in brain function. In Nigeria several multi-sector programmes are being implemented and some of these reflexively promote neurodevelopment in the first 1000 days of life. Some of these programmes include essential nutrition actions, infant and young child feeding, maternal, newborn and child health week, salt iodisation, food fortification, bio-fortification, supplementation programmes, nutrition education among others.

Introduction
The right to a standard of living adequate for the health and well-being including

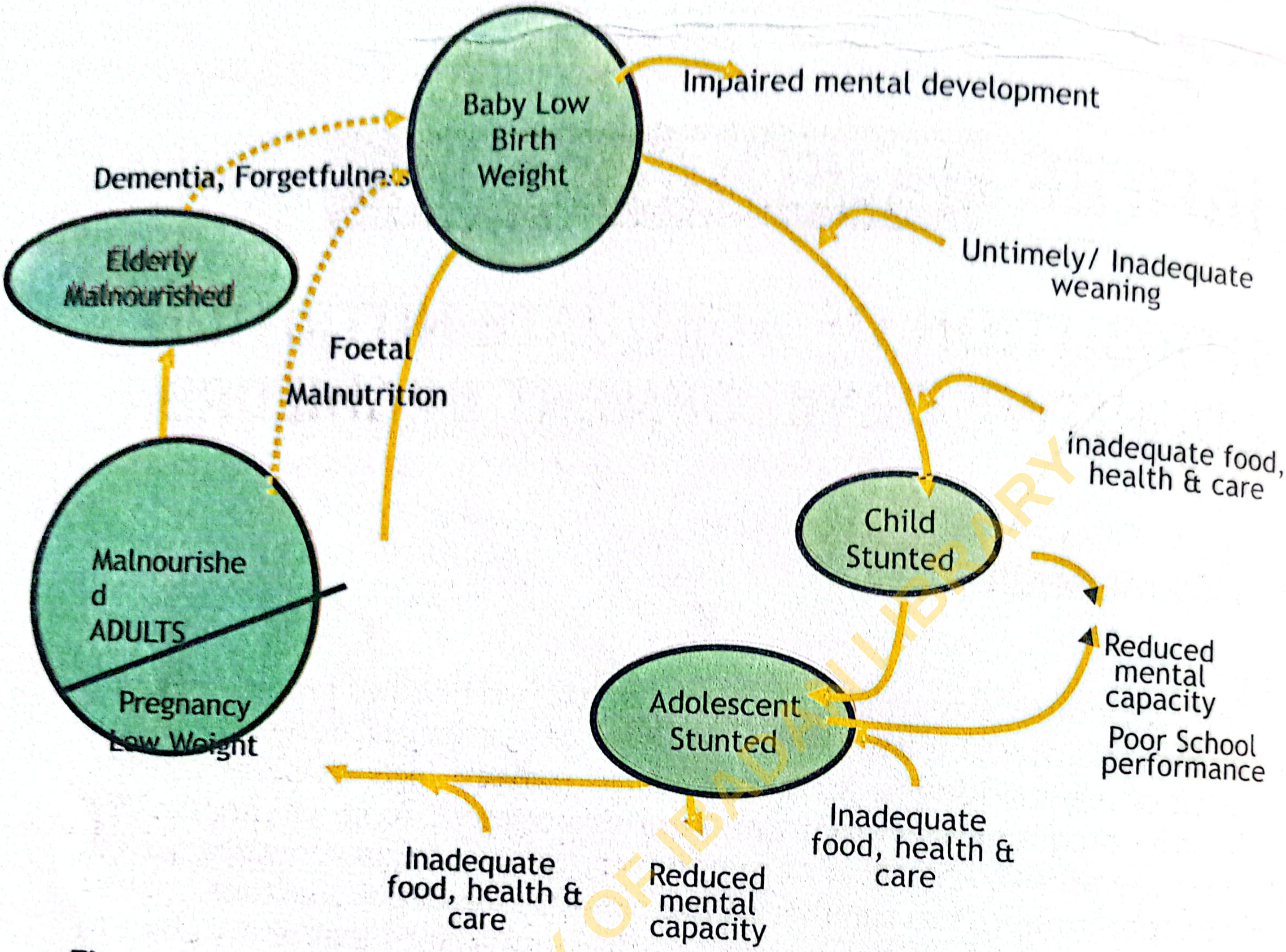


Figure 1. Consequences on malnutrition on cognitive performance across the life cycle
(Adapted from United Nations Administrative Committee on Coordination. Sub-Committee on Nutrition. (1998). Challenges for the 21st. century: a gender perspective on nutrition through the life cycle. In *ACC/SCN Symposium Report. Nutrition Policy Paper* (No. 17).

The brain in the first 1000 days of life

The first 1000 days of life refers to the period from conception (*conception to delivery: 259-294 days*) to the age of two years (*approximately 730 days*) and is acknowledged as the most active period of neurologic development[3] (See Figure 2).This period is distinct because it has specific nutritional requirements and small deficits may significantly influence growth, development and later health. This scenario makes maternal health and nutrition the starting point of promoting adequate infant and child health and cognitive development. It is important to ensure good maternal nutrition prior to pregnancy as evidence has shown that brain and nervous tissues development start shortly after conception (Figure 3) **(before many women in developing countries recognise the pregnancy).**

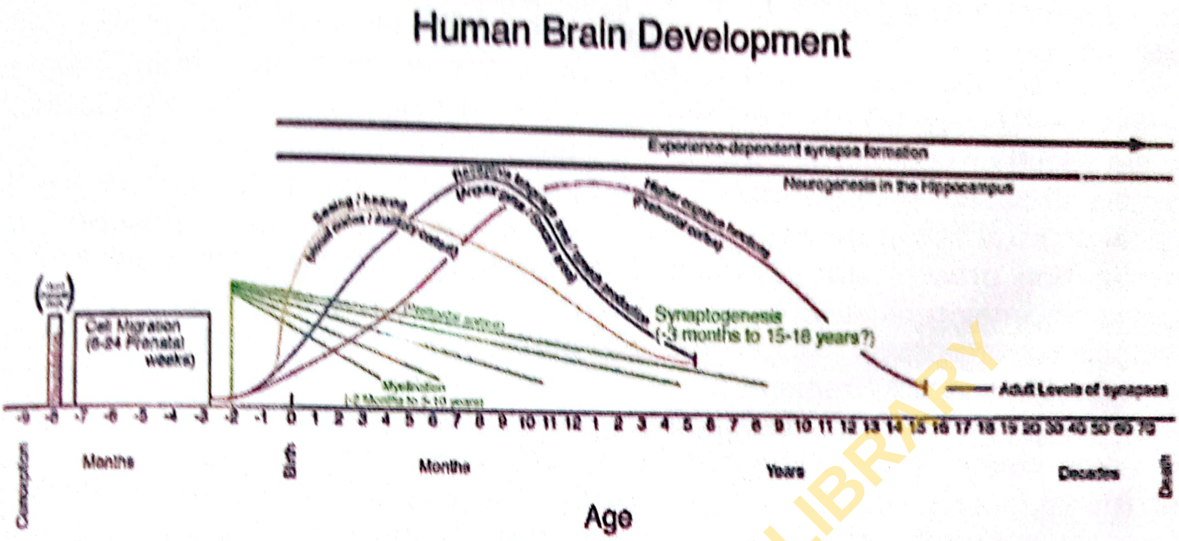


Figure 2. Human Brain Development from conception to death

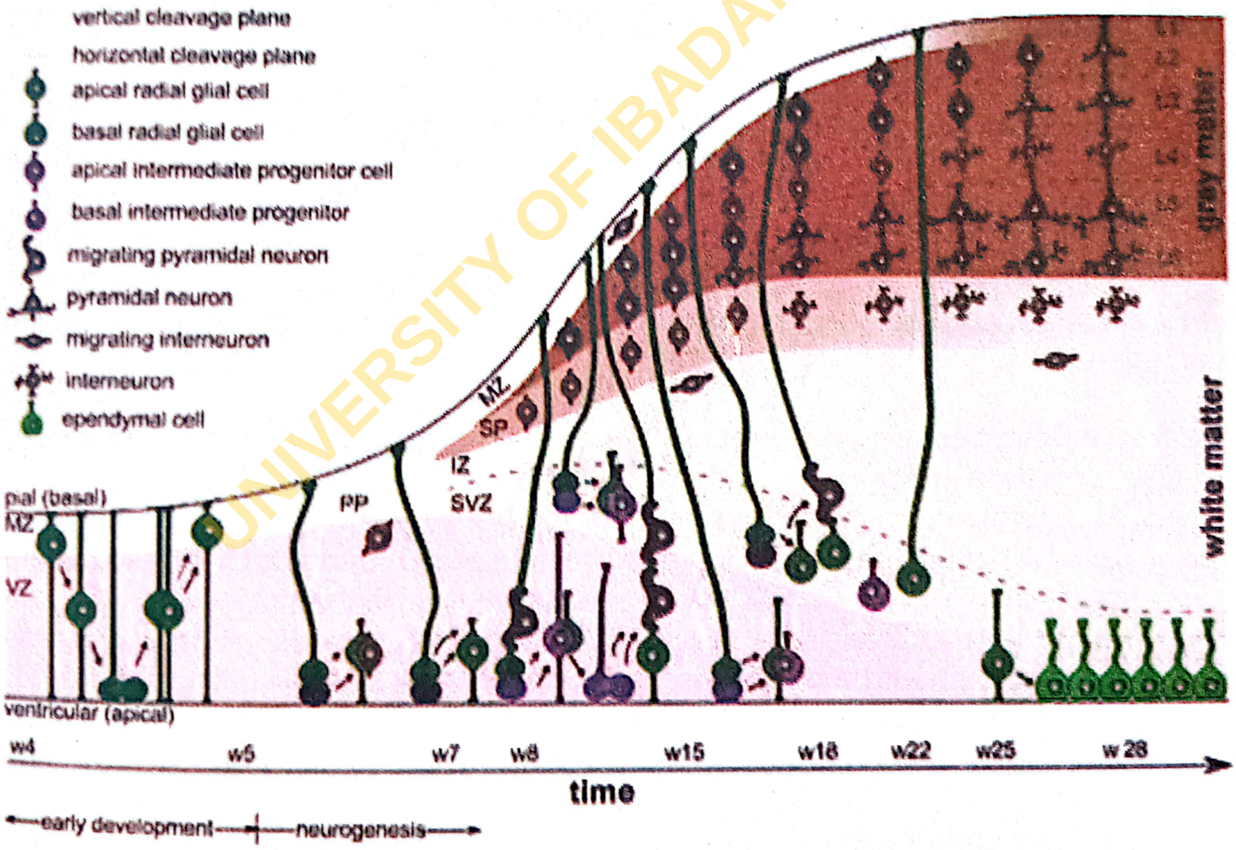


Figure 3. Early development and neurogenesis of human brain
Source (Budday, S., Steinmann III, P., & Kuhl, E. (2015). Physical biology of human brain development. *Frontiers in cellular neuroscience*, 9, 257.)

The development is rapid throughout pregnancy such that an infant brain weighs one-quarter and three-quarter of an adult brain at birth and at two years respectively. The ectoderm that develops to the neural tube is identifiable by week 4; and by week 5, the neural plate at the back side of the embryo is formed[4]. About 20 billion neurons are in place between week 7 and 22 of pregnancy through neurogenesis, nerve fibers and synapse formation commence by week 24 and the cortex is established by week 35[5]. During the last few weeks of gestation, the myelination process starts, which is essential for proper development, fine-tuning, and maintenance of brain function[4,5].

The brain development is sequential and interwoven; alterations or delays at any stage could impact subsequent processes, hence, prevention of inhibitory factors is crucial for healthy brain development. Healthy brain development is dependent on environment (socio-economic), gene (interpersonal and/or family), and nutritional factors[6]. Interestingly, nutrition is the most easily modifiable factor of these three factors. Nutrition influences the rate at which brain growth and differentiation occurs. Both inadequate and excess supply of nutrients predispose to poor brain growth and differentiation and severity could be higher where dual burden of malnutrition exists[7]

Specific nutrients and significance in neurodevelopment

There are four major milestones in neurodevelopment process and certain nutrients including protein, zinc, iron, folate, iodine, vitamins A, D, B_6, and B_{12}; and long-chain polyunsaturated fatty acids have specific roles at different phases of these milestones. When supply of these nutrients falls below requirement particularly at critical period of brain development, lifelong deficits in brain function results.

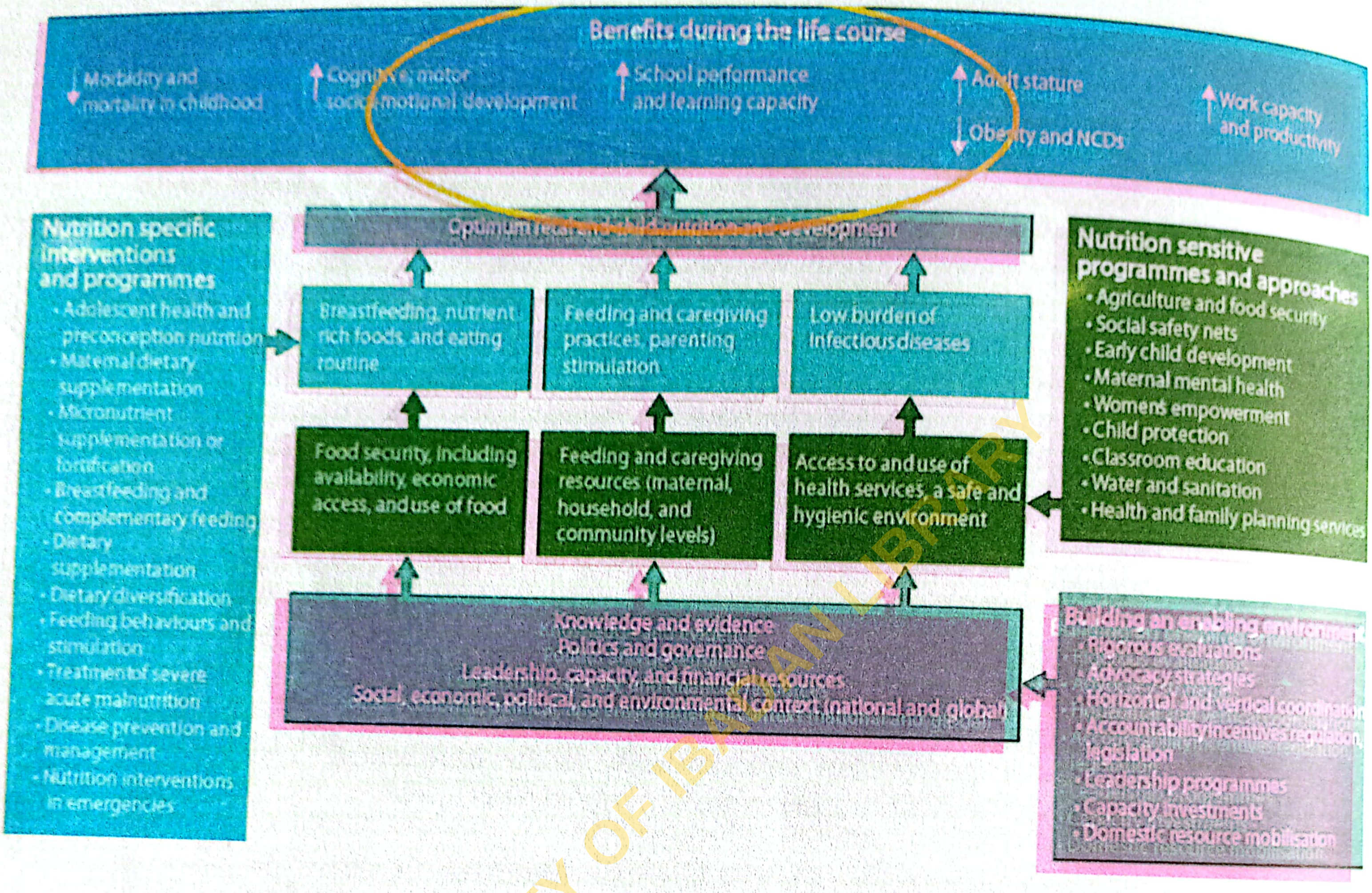
The four milestones are proliferation of neurons, growth of axon and dendrite, synapse formation and pruning, and myelination[8, 9]

1. Proliferation of neuron begins in week 7 of gestation and continues to at least 4.5 months postpartum as a product of cell division that leads to the creation of new cells[10]. Studies have shown that malnutrition restricts cell division and consequently proliferation of neuron[11].Protein energy malnutrition and excessive supply of zinc have been reported to inhibit cell division and consequently proliferation of neurons[12, 13]. Protein energy malnutrition impairs homeostatic proliferation of memory CD8 T cells[14]. Human studies have also shown fewer brain cells among infants with intra uterine growth which is indicative of protein energy malnutrition[15]. Early alteration of structural and functional brain development in premature infants born with intrauterine growth restriction. In addition, lipids are sources of fatty acids which are important for the synthesis of

phospholipids[16]. These phopholipids are required for neurogenesis. Iodine is an important component of the thyroid hormone and this is important for cell migration[17].

2. Axon and dendrite growth require optimum nutrition, thus the history of protein energy malnutrition among other nutritional deficiencies could limit transmission. Poor branching of the axon and dendrite have been identified among children with moderate acute malnutrition, iodine and iron deficiencies[18].
3. Synapse formation and pruning: The synapse connects the axons, dendrites and the cell bodies and serves as the neurotransmitters. Several nutrients are required for the formation and functionality of the synapse[19]. Thus undernutrition during pregnancy and postnatal results in fewer synapses and alterations in synapse structure[20, 21]. Many fatty acids such as docosahexanoic and arachidonic acid and micronutrients such as zinc[22], iodine[17], iron[23] and vitamin B6[24]are important in the maturation of synapses[25].
4. Myelination: The abundance of myelinated nerve cells gives the grain its characteristics white colour and this serves to enhance the speed of transmission of electrical impulses. Impaired myelinations has been reported in gestational and postnatal iodine deficiency[17,26], vitamin B6 deficiency[27] and intra uterine growth retardation[15].

These stages characterised the key target nutrients for cognitive development to include protein and energy, lipids with emphasis on the fatty acids, iron, zinc, iodine, and selected B6. The need to promote the grey matter and ensure adequate mental development has been prioritised in many developing programmes. To this end, several nutrition specific and nutrition sensitive programmes are in place to promote maternal and child nutrition. A programme is considered to be nutrition-specific when it addresses the **immediate determinants** of fetal and child nutrition and development and nutrition-sensitive if it addresses the **underlying determinants** of fetal and child nutrition and development **and incorporate specific nutrition goals and actions**[28]. This article will focus on the nutrition specific programs with possible impact on the cognitive development.



Source: Ruel, M. T., Alderman, H., & Maternal and Child Nutrition Study Group. (2013). Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *The Lancet*, *382*(9891), 536-551.

Pragmatic actions in Nigeria

In many developing countries, there is increasing engagement of several key players in ensuring adequate nutrition and promoting healthy neurodevelopment. Several multi-sectoral policies, programmes and projects using a lifecycle approach are being put in place to ensure healthy starts and supportive environment for adequate mental development of infants and young children. In the last few years, there has been tremendous support and increased attention on nutrition sector and many development partners have raised African leaders' interest in promoting 'grey matter' development. In Nigeria, attention has been focused reflexively on specific nutrients that are considered important in promoting cognitive development. Some of these programmes provide multiple platforms to promote adequate supply of key nutrients for healthy neurodevelopment.

The Essential Nutrition Actions (ENA) is an approach to expand the coverage of six proven nutrition interventions through actions at health facilities, in communities, and through communications channels (Exclusive Breastfeeding (EBF) for six months; Adequate complementary feeding (CF) from about 6-24 months with continued BF for at least two years; Appropriate nutritional care of sick and severely malnourished children; Adequate intake of vitamin A for women and children; Adequate intake of iron for women and children; and Adequate intake of iodine by all members of the household[29]. Infant and young child feeding programme also articulated these concepts and promote both exclusive breastfeeding and appropriate complementary feeding practices including sustaining breastfeeding for up to the age of 24 months at least. Evidences have consistently shown that breastfeeding enhances children's cognitive function[30, 31] and that duration of breastfeeding affects intelligence[32]. Despite these benefits, only 40.0% of infants less than six months of age globally are exclusively breastfed[33] and 66.3% of infants in Nigeria missed the benefits of EBF[34]. Exclusive breastfeeding (EBF) is the feeding of an infant with breast milk only excluding all other foods such as solids or liquids, including water except prescribed medications during the first 6 months of life[35]. Support for early initiation, exclusive breastfeeding of infants for six months, and continued breastfeeding for two years has the potential to supply the fatty acids, zinc, vitamin B6 and macronutrients needs to promote healthy cognitive development. The promotion of appropriate complementary food involves ensuring compliance with the recommended minimum dietary diversity, meal frequency, quantity and timing. Adequate iron intake for women and children contributes to healthy nutritional environment.

Infant and young child feeding includes promotion, counselling and support for exclusive breastfeeding for six months and continuing breastfeeding with appropriate complementary food. Micronutrient powder distribution helps stimulate complementary feeding. This component of the nutrition programme, also carried out through CMAM, includes training of health workers. In addition, the introduction of the multiple micronutrient powder in Nigeria has substantially enhanced the diet quality of local complementary diets. This in turn improves the likelihood of adequate supply of micronutrients by well fed infants.

Other notable programmes with potential to contribute to cognitive development in Nigeria are; nutrition education for adolescents, maternal micronutrient supplementation, dietary diversification, community management of acute malnutrition, supplementary feeding and counselling, maternal and newborn child health week, distribution of multiple micronutrient powder, food fortification programme, bio-fortifcation, school feeding programme and so on.

Conclusion

There is abundant evidence to show that nutrition affects cognitive development from early gestational period and malnutrition could cause irreversible damages. Efforts need to be heightened to promote adequate female adolescents, maternal and child nutrition. Existing programmes should be strengthened and scale up to reach more beneficiaries.

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