World Hunger, Malnutrition and Brain Development of Children

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Abstract

Hunger is still a major problem faced by people in the world especially in some areas in developing countries, and this condition is a cause of undernutrition. Insufficient nutrition during the early stages of life may adversely influence brain development. It was observed from my own research conducted in Bogor, Indonesia, that children with severe acute malnutrition (SAM, body mass index or BMI for age z score < -3) (N=54) had significantly (p<0.05) lower memory ability score (46.22±1.38) compared to normal children (BMI for age z score -2 ≤ z ≤ 1) (N=91) (51.56±1.24). Further, children with Moderate Acute Malnutrition (MAM, BMI for age z score -3 ≤ z <-2) tended to (p<0.1) have lower memory ability (50.08±1.58) than the normal children. On the other hand, overnutrition among children also might impair the brain function. The study revealed that children who are overweight (BMI for age z score 1 < z ≤ 2) (N=8) significantly (p<0.05) had lower memory ability score (46.13±4.50) compared to the normal children. This study also revealed that obese children (BMI for age z score > 2) (N=6) tended to (p<0.1) have lower memory ability score (50.33±5.64) than the normal children. It is therefore very important to maintain children at a normal BMI, not being undernourished (SAM and MAM categories) on one side and not being overnourished (overweight and obesity categories) on the other side in order to optimise their brain development. This could be achieved through providing children with an adequate and balanced nutrient supply via food.

Keywords: *Hunger; Malnutrition; Brain development*

Introduction

World hunger is a condition in which the substantial world population undergoes undernutrition as a result of food scarcity (Halford et al., 2005: 1015). FAO (2012: 8) have estimated that there are about 870 million hungry people worldwide in 2012, which means that one in eight people is undernourished. Hunger has been the top world problem for many decades. World hunger has reduced from 18.6% in 1990-92 to 12.5% in 2010-2012. However, the progress has slowed down since 2009 due to the economic crisis (FAO, 2012: 8). Most of the people suffering from hunger are from developing countries; that are about 850 million people which account to almost 15% of the population (FAO, 2012: 8; Figure 1).

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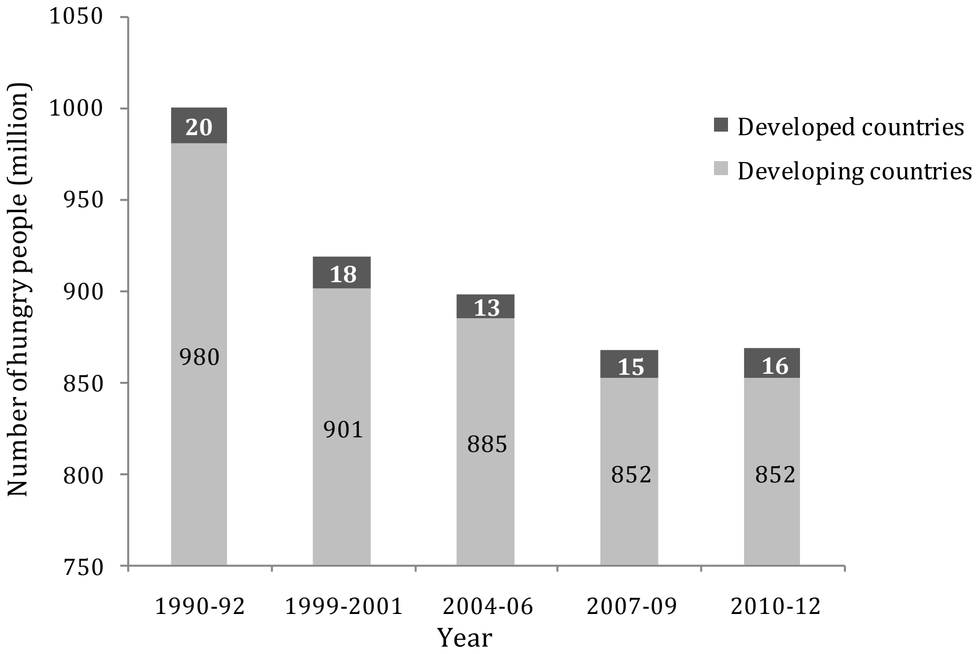

Figure 1. Number of world hunger from 1990 to 2012.
Source: Adapted from FAO (2012: 9).

People who suffer from hunger, either chronically or acutely malnourished, are mainly located in Sub-Saharan Africa and some areas in Asia. A number of reasons have been the driving forces of world hunger, i.e. limited access to sufficient quantity and quality of food, starvation due to famines, war and natural disasters, low agricultural productivity, poverty and unemployment, and some micronutrient deficiencies (Sanchez and Swaminathan, 2005: 357). More specifically concerning the hungry, approximately half of them are small-holder farmers. About 20% of the hungry are the landless rural and 10% are pastoralists, fishers and forest dwellers. The rest of the figure is made up by the urban hungry (Sanchez and Swaminathan, 2005: 357). The respective problem, i.e. hunger is associated with undernutrition (a type of malnutrition; the other one is overnutrition) in which people do not get sufficient nutrients for supporting normal life. In the case of children, hunger may impair their brain development which then may threaten its normal function. Multidisciplinary, integrated and systemic approaches are needed in order to combat world hunger. Therefore, many discussions and researches on this topic will become precious and be demanded in order to gather valuable findings and solutions for a better quality of life for the next generation. Accordingly, this article attempts to discuss the relationship between hunger, malnutrition and brain development of children based on literatures and current research results.

The fact of world child hunger

Children are the actors who suffer most from the world hunger. Sanchez and Swaminathan (2005: 357) have identified children, in particular underweight children less than 5 years of age as a substantial hunger hot spot.

Further, more than 2.5 million children, equivalent to 1 in every 22 children, die every year due to world hunger (FAO, 2012: 4; UNICEF, 2007: 11). And it has left many generations with irreversible physical and mental disabilities (Black et al., 2008: 1). However, nowadays feeding more than 7 billion people in the world adequately is getting more challenging due to population growth and climate change (Black et al., 2008: 6; Stoddart, 2013: 33). Food supply is getting scarce due to a number of natural phenomena, i.e. drought, flood, deforestation, crop failure, and water supply (WHES, 2013; Black et al., 2008: 6). In turn, insufficient nutrient supply due to world hunger problem may negatively influence the brain development of children which may further threaten their future.

Mainly, there are three indicators of child hunger. Those are stunting (height below normal), underweight (weight below normal) and wasting (ratio weight to height below normal). UNICEF (2012) reported that on the global scale, as many as 165 million children under five, or 26%, were stunted (height for age below -2 SD from normal standard) in 2011. Most of them live in Africa (36% in 2011) and Asia (27% in 2011). Trend shows a reduction pattern, that is 35% decrease from 253 million in 1990. However, stunting is still a major public health problem in Africa and Asia, even it often occurs as a hidden malnutrition. Most African and Asian are stunting (UNICEF, 2012: 1). As many as 101 million children under five, or 16%, were underweight in 2011 (weight for age below -2 SD). The trend of being underweight was also reduced 35% from 159 million in 1990. However many children are living under wasting risk (UNICEF, 2012: 1). And in 2011, as many as 52 million children under five, or 8%, were wasting (weight for height below -2 SD). This was a 11% reduction since 1990 (UNICEF, 2012: 1). Most of them (70%) coming from Asia who live under the risk of severe acute malnutrition (SAM) and death.

At the same time, there has been the emergence of other types of malnutrition, i.e. overweight and obesity (weight above normal) as a result of long term overnutrition. The prevalence of obesity among children and children being overweight is rising. Is was estimated that 43 million children under five, or 7%, were overweight and obesity (weight for height above +2SD from normal standard) in 2011 (UNICEF, 2012: 1). The trend is increasing sharply, about 54% from 28 million in 1990. Surprisingly, this phenomenon occurred not only in developed countries, but also in many developing countries. Obesity is found almost all over the world (UNICEF, 2012: 1). The prevalence in 2011 was 7% in Africa (12 million) and 5% in Asia (17 million) (UNICEF, 2012: 1).

The above fact presents the respective double burden of malnutrition, i.e. undernutrition and overnutrition has become the current phenomenon. More than 25% of the world children live undernutrition, in which they grow up with many risk of impairment, discapabilities and morbidities which then will reduce the quality of the next generation. It will leave many generations less productive than they would have been. Even though its pattern is decreasing, its prevalence still remains high and remains a world problem. With the undernutrition problem remaining unsolved, the over nutrition problem emerged, not only

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among child but also mothers and adults. Figure 2 ilustrates the decreasing pattern of the prevalence of stunting and underweight among children under five. It also shows the increasing pattern of prevalence of overweight and obesity among children under five.

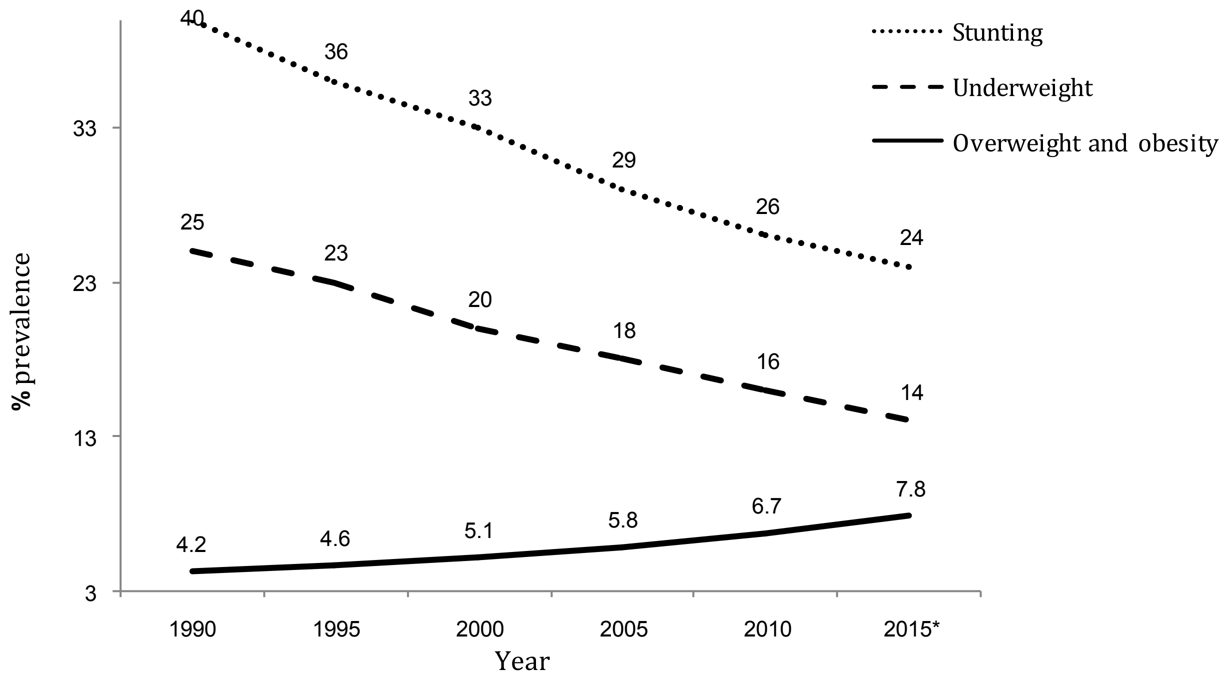

Figure 2. Prevalence of stunting, underweight, and overweight and obesity among children under five years old on the global scale, 1990-2015.
Source: Adapted from UNICEF, 2012: 11; de Onis et al., 2010: 1260. Note:*Estimation number.

It was estimated that 1000 million people were suffering from overweight and obesity, and 300 million people suffering from obesity (Steinfeld et al., 2006: 271). Surveys in 2008 showed that prevalence of obesity in Europe is 22% (Perez-Cueto et al., 2010: 156). In Australia in 2003, 60% of adults were overweight or obese, which the rate in 2008 was 2.5 times higher than in 1980 (Dunn et al., 2008: 331). A study in USA in 2000 reported that 2 of 3 US adults are overweight or obese (Glanz et al., 1998: 1118). The increasing trend alarms the world. Overnutrition might cause many chronic diseases, like cardio-vascular disease, diabetes, and certain types of cancer (Steinfeld et al., 2006: 269; McAfee et al., 2010: 1). However, childhood obesity is very important to be monitored. This type of childhood malnutrition is associated with serious health problems and the risk of premature illness and death later in life (de Onis et al., 2010: 1257). The respective double burden of malnutrition, both under- and over-nutrition, is the current world problem and needs to be solved.

Malnutrition and child brain development

Adequate nutrition intake is crucial for human health and development. Better nutrition is correlated to the better life, both physically and mentally (WHO 2011). Along the period of life, childhood is the most sensitive period toward the nutrition intake quality. Childhood is the period in which the human is growing and developing. Studies reported that inadequate nutrient intake during the first five years of life may influence the brain development which is not possible to be paid-off on the next period of life (Thompson and Nelson, 2001: 8; Besty and Georgieff, 2006: 158; Strain et al., 2008: 776; Wainwright, 1992: 193). The following paragraphs present the process of human brain development in normal children and the research findings of the impact of undernutrition and overnutrition on brain development.

A normal growth child – in the terms of a child with adequate nutrient intake – will achieve 80% of his adult brain weight in their first 2 years, and achieve 90% in their first 5 years (Dekaban and Sadowsky, 1978: 355; Lenroot and Giedd, 2006: 720). Similar to the rest of the body, the brain is constructed from protein, fat, carbohydrate, vitamins and minerals which are essentially supplied by the diet. Since brain develops faster than the rest of the body, a dietary deficiency (due to hunger or undernutrition) during a critical stage of development may result in lasting changes in brain structure and function (Benton, 2010: 457). Therefore, undernutrition especially for under five children threatens the quality of the next life, not only for their own life, but also the quality of the next generation as a cumulative society (WHO 2011; Dekaban and Sadowsky, 1978: 355).

Thompson and Nelson (2001: 8) gave a best illustration regarding the developmental of human brain along human life (Figure 3). Brain development starts one month after conception, when the brain and spinal cord were formed within the embryo, this process is called neurulation (Thompson and Nelson, 2001: 8; Thompson, 2001: 28; Ulmer et al., 2013: 615). Then the cell continues to migration. Almost all neurons were formed at the sixth gestation month. During this stage as many as 250 thousand neurons were generated per minute which then quickly migrate to the brain region where they will function (Thompson, 2001: 28).

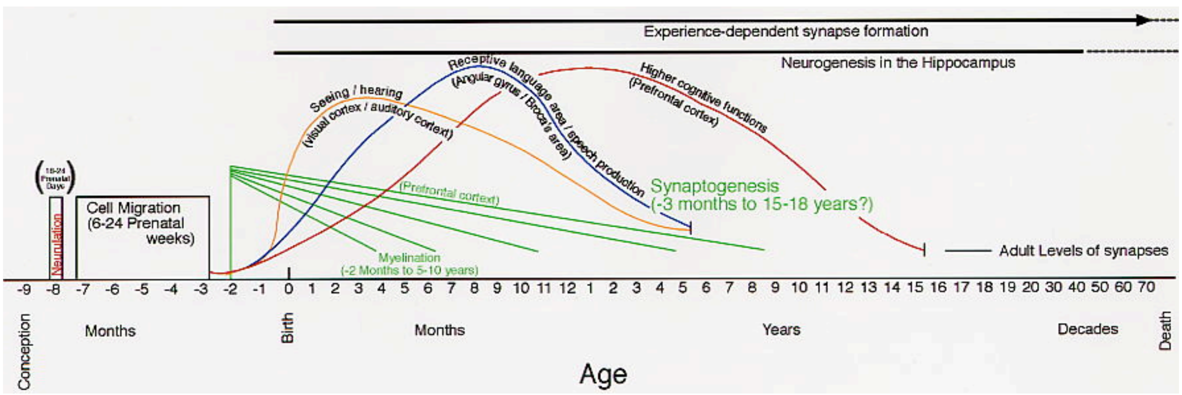

Figure 3. Human brain development along the human life. Source: Thompson and Nelson (2001: 8).

The neurons then differentiate to place a specialised roles and form synapses to connect with the other neurons for communication and store information. This process is called as synaptogenesis which starts 3 months before birth and continues throughout childhood. Georgieff (2007: 6146) mentioned that this gestation period is very vulnerable to nutritional insults due to the rapid trajectory of synapse formation and myelination. By the moment of birth, the major neurons were appropriately located within immature brain and it has begun to function like mature brain (Thompson and Nelson, 2001:8; Thompson, 2001: 28).

A significant changes and development of brain would be expected after birth. Synaptogenesis occurs particularly in the visual system and hippocampus (Georgieff and Innis, 2005: 99R). The formation and induction of synapses, which makes neurons, communicate with other neurons, and continuously develops during this stage. This proliferation makes the brain more functioning and "connected" (Thompson, 2001: 28). On the young brain these connection was made the brain to much crowded. Therefore along the stimulation and learning process, some of connection is reduced to make the system more efficient. This process is similar to the motto "use it or loose it"[1]. Connections which are not activated are then progressively reduced . Along the human life, the neurogenesis formation and synapses formation might occur, depending on the human experiece (Thompson, 2001: 29).

However the brain formation and neuron formation and initiation only occur during the early life development. During this formation, the brain needs adequately good quality nutrition as a raw material (Thompson, 2001: 29). Nutrients are required in specific metabolic pathways and structural components (Georgieff, 2007: 6146). Therefore, insufficient nutrition and stimulation during this stage might impair the brain development process which could not be paid off on the later life. Georgieff (2007: 6145) mentioned that there are certain nutrients that have greater effecs on brain development than others have. Those nutrients are protein, energy, certain fats, iron, zinc, copper, iodine, selenium, vitamin A, choline and folate.

Insufficient nutrition during the early stage of life might influence the brain development. A child's early life period is very susceptible to nutrient deficiencies (Georgieff and Innis, 2005: 99R). Georgieff (2007: 6145) briefly explained how nutrient deficiency can influence brain development on early life. Protein-energy, iron, and zinc malnutrition all affect the development of hippocampus and cortex (Georgieff, 2007: 6146). Hippocampus together with amigdala and prefontal cortex is essential for memory processes and emotions (Shin et al., 2006: 70). Hipocampus is one of the earliest areas to show cortical-cortical connectivity and functionality (Georgieff, 2007: 6146). Nutrient deficiency in the early stages can affect differentiation in this area which influences the cells numbers and complexity, which then affect the functionality (Georgieff, 2007: 6146).

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[1] "Use it or lose it" is a slogan by Slow Food® to protect endangered products by promoting people to consume them so that might save biodiversity from on going lose.

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De Souza et al. (2011: 135) mentioned that brain development status is possibly to be assessed according to some cognitive performance indicators. Those indicators are memory, learning, and attention ability. A cross sectional study conducted in Bogor-Indonesia (Palupi et al., 2013) revealed that children with Severe Acute Malnutrition had significantly ($p<0.05$) lower memory ability score (46.22±1.38) compared to normal children (51.56±1.24). Children with Moderate Acute Malnutrition tended to ($p<0.1$) have lower memory ability (50.08±1.58) than the normal children (Table 1; Figure 4; Palupi et al., 2013). This result obviously presents that undernutrition during early life affects their cognitive ability. In this study, undernutrition (SAM and MAM groups) occurred due to lower protein intake from total food, but not from energy, carbohydrate and fat intake.

Nutritional status	**BMI-for-age z score**	**Number**	**Percent**	**Memory ability**		
				Mean	±	SD
SAM	< -3	54	24.43	46.22	±	10.12a
MAM	-3 ≤ z < -2	62	28.05	50.08	±	12.48ab
Normal	-2 ≤ z ≤ 1	91	41.18	51.56	±	11.85b
Overweight	1 < z ≤ 2	8	3.62	46.13	±	12.74a
Obesity	> 2	6	2.71	50.33	±	13.84ab

Table 1 Mean value of memory ability by nutritional status (SAM, MAM, normal, overweight and obesity)

Note: BMI: body mass index; calculated as kg/m2, SAM: Severe Acute Malnutrition, MAM: Moderate Acute Malnutrition. Source: Palupi et al., 2013

On the other hand, overnutrition among children also might impair the brain function. The study conducted in Bogor-Indonesia revealed that children who are overweight significantly ($p<0.05$) had lower memory ability score (46.13±4.50) compared to normal children (51.56±1.24). This cross sectional study also revealed that obese children tended to ($p<0.1$) have lower memory ability score (50.33±5.64) (Table 1; Figure 4; Palupi et al., 2013). Such overweight and obesity in this study were partially due to higher consumption of the respective groups on formula milk, but not the breast milk. Further, higher energy, protein, carbohydrate and fat intake on these groups were observed as compared to those of normal BMI group. The less lower memory ability score of obese children compared to overweight children needs to be confirmed with further larger sample size survey.

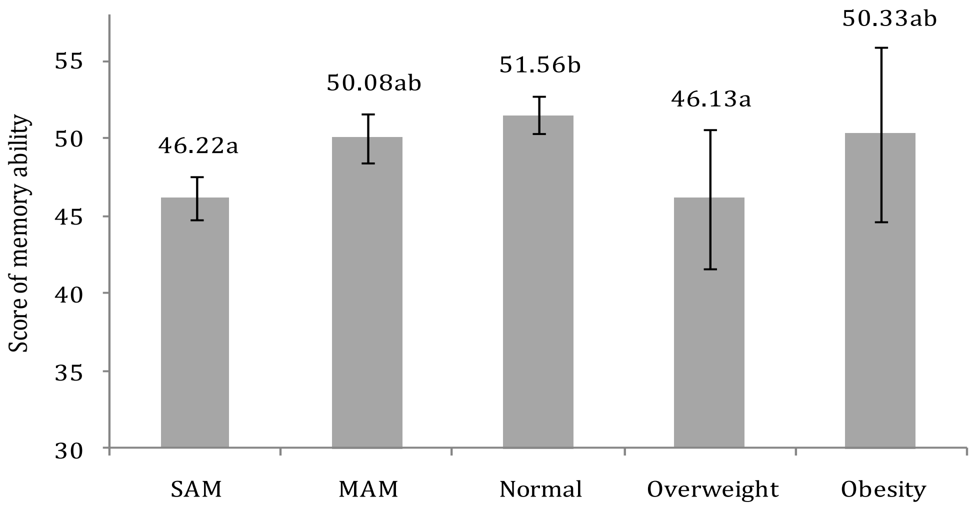

Figure 4. Score of memory ability by BMI for age z score of children with category Severe Acute Malnutrition (SAM), Moderate Acute Malnutrition (MAM), normal, overweight and obesity. Source: Palupi et al., 2013.

A narrative review conducted by Burkhalter and Hillman (2011: 203S) confirms that finding, i.e. the inverse relationship between obesity and cognitive performance. The authors explained that overnutrition, in particular an overnutrition of energy is maladaptive to brain health and function; obese children had a lower intelligence score as compared to the normal children. Further, such lower academic performance may persist when the obese children are getting mature into their teens. The reason on why obese children possess lower cognitive performance is considered due to changes in brain structure. Accordingly, BMI higher than 30 was associated with atrophy in the frontal lobes, the anterior cingulate gyrus, hippocampus, an thalamus relative to individuals with normal BMI (between 18.5 to 25). Obesity is associated with a decrease in brain volume which leads to lower attention, memory, control of cognition and scholastic performance (Burkhalter and Hillman, 2011: 203S). It is therefore very important to maintain children at a normal BMI, not being undernutrition (SAM and MAM categories) on one side, nor being overnutrition (overweight and obesity categories) on the other side.

Conclusion

When hunger occurres to either pregnant women and/or the children, it is a cause of undernutrition and such condition leads to impairment of brain development. On the other hand, overnutrition is the other opposite that also lowers cognitive performance of children. Providing children with an adequate and balances nutrient supply via food is therefore essential in order to optimise their brain development, especially during its critical stage. In the global context, the causes of under- and over-nutrition has to be opposed through integrated and systemic approaches for a better quality of the next generation of human beings.

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