

Can Food Insecurity Affect Cognitive Performance of School Children?

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Abstract The present thematic review tries to find out the association between food insecurity and cognitive performance among school children. Cognitive performance includes a wide range of mental functioning that recruits basic processes such as attention and alertness, remembering, problem solving, reading and mathematical skills. The review analysis showed that food insecurity can affect cognitive performance through direct relationship of nutritional factors such as animal source protein (milk and meat) with mental functioning. Further, psychosocial factors which include socioeconomic status, is expected to have an indirect effect on students' cognitive performance. The analysis also proved developmental effect of food insecurity, if it occurs in early stages of education (kindergarten) it will affect the later cognitive performance of school children. The study recommended special emphasis on food security situations for poor and vulnerable households. Moreover, aiming at economic growth, special consideration for factors negatively affecting food security, nutrition and cognitive performance of school children is recommended.

Keywords Mental functioning, Academic achievement, Household food insecurity, Poverty and nutrition, Socioeconomic status

1. Introduction

Poverty is one of the main threatening factors to the human wellbeing. Based on (Engle and Black 2008), poverty at early stages of life affects the educational and developmental outcomes of children both directly and indirectly at later stages even if households escape poverty. Food insecurity is inevitable consequence of poverty and economic hardship. Food insecurity influences children's wellbeing, it would lead to poor quality of diet, which proved to be significantly great barrier to physical activity with expected consequences on developmental issues ((Fram, Ritchie et al. 2015)).

The food access dimension of food security is defined by (FAO 2006, June) as "Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Entitlements are defined as the set of all commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources)".

Based on (Cook J. 2013) child food insecurity is detrimental to mental and physical health of children at all

stages of childhood, however, the first 3-4 years of life, when brains are growing rapidly are more affected. Based on analysis, food insecurity influences health through two main pathways, namely nutrition and non-nutrition pathways. The nutrition pathway is related to the food intake in terms of kind, amount, and quality of food, whereas the non-nutrition path is related to food sources and psychological factors including, eating habits and behavior. The impact of food security on human capital is expected to influence the achievement of national economic wellbeing.

According to (Cook and Jeng 2009) food insecure children growing up in food insecure households lag behind in terms of cognitive development compared to their food secure peers. Food insecure children suffer disadvantageous position regarding cognitive performance, they tend to receive lower scores in mathematics in kindergarten and poor learning in math during school years, the negative impact may lead to grade repetition or the child may be sent to special education at the worst end. The child may have lower IQs (Intelligence Quotient) according to (Belsky, Moffitt et al. 2010).

Cognitive performance is a mental action based on cognition, which is defined by (Neisser 1976) as "cognition is the activity of knowing: the acquisition, organization, and the use of knowledge". When the school child performs language or arithmetic tasks, pays attention to his/her teacher, perceives and understands the lessons and retrieves its parts and contents, he/she is actually activating all the processes

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mentioned in Nieser's definition of cognition. Acquisition, organization and the use of knowledge constitute the concept of learning which considered to be the main task of school cognitive performance.

Learning with school curricula demands a range of cognitive and neural processes, as stated by Tolmie (2011). When we talk about reading skill as a basic process for school learning and achievement, it is a complex job to perform and master. Reading requires using pre-attentional processes. For instance, to pick up information we move our eyes around the text, then the information needs to be integrated on an active manner within working memory to be processed for meaning, then the meaning extracted and encoded to find its place in long term memory. Reading needs prior knowledge based on the sequence and aspects of language development that provide the child with basic tools of learning to read.

Learning mathematics is also a basic job for school children to perform and master. Similar to reading, learning mathematics takes place in early stages of child cognitive development when the child begins to perceive numbers and practice counting and some of basic operations when he/she uses addition, subtraction, multiplication and division. Those abilities develop gradually and take their obvious form when the child starts school, they represent the ground for further arithmetical skills and assimilation of number facts or any new mathematical principles (Tolmie, 2011).

Regardless of the school learning type, every learning situation needs a reasonable level of attention. Attention capacity is one of the basic cognitive abilities that equips students of all ages for a good school cognitive performance. Children from food insecure household are two times more likely to have symptoms of hyperactivity disorder which include mainly attention deficit, leading to a poor learning and memory processing, consequently, low levels of school achievement (Melchior, Chastang et al. 2012). Learning situations engage motivational factors, such as children's self-control and task persistence which affects the school performance critically, and evidenced to be affected by food insecurity, motivational factors could undermine the effectiveness of classroom-based learning (Howard, 2011).

The contribution of the present review may be represented in providing the impulse for more comprehensive approach to the negative effects of food insecurity on the cognitive performance of school children and how they affect their optimal learning. The inclusion of nutritional factors and psychosocial dimensions may improve the intervention programs at any level of services that are made to cope with the problem.

2. Cognitive Performance, Food Insecurity and Nutrition

Based on (Ross 2010), eating healthy food is essential for students to attain their mental growth and full academic

potential. He recommends commitments by school to provide quality meals offering the energy and nutrients required for achieving maximum potential. According to (Gómez-Pinilla 2008), brain health and mental function are influenced by surrounding environment including diet. In particular, special nutrients affect cognition by acting on molecular systems, which are essential for performing cognitive functions.

(Growdon and Wurtman 1980) argued that recent research on nutrition indicated a link between brain's ability to form and release many of its neurotransmitters. Hence, from the above studies, nutrition is of paramount importance for brain functioning and capacity of students to develop cognitive and mental activity.

Aiming to explore the relationship between dietary fat intake and food insufficiency with the effect of cognitive functioning in school age children, (Rausch 2013) analyzed a number of articles that demonstrate the impact of poor nutrition on school-age children. Based on results, a healthy balanced diet upgrades brain capacity, improves academic performance and maximizes cognitive capabilities in school-age children.

(Whaley, Sigman et al. 2003), tested the impact of three variable diets on the cognitive development of school children in Kenya. The sample of the study contains twelve schools with a total of 555 students from standard 1 level that were randomized to one of 4 feeding interferences including meat, milk, energy or no feeding resembling control. The experiment continued for 7 school terms and cognitive tests were performed before and after feeding. Hierarchical linear random models were employed to test the effects of treatments on cognitive performance overtime. Results indicated that children who receive food supplemented with meat showed higher performance compared to all other children as indicated by Raven's Progressive Matrices. In addition, children supplemented with meat and those supplemented with energy showed higher performance in relation to control group. Hence, results indicated that supplementation with animal source food proved positive effects on children's cognitive performance in Kenya. The above results are in line with (Gómez-Pinilla 2008) results of the importance of special types of diets which have direct impact on cognitive performance.

(Hannum, Liu et al. 2014) mentioned significant long term effects of food insecurity on school achievement, specifically literacy scores in China. They analysed children performance in literacy, drawing a sample from 100 Chinese villages, their survey included food secure and food insecure children. The lower achievement in prior literacy scores of food insecure children in pre-schooling has negative effects on early years in school. They reached the conclusion that poverty, food insecurity and continuous undernourishment play a significant role in transmitting educational disadvantage in China. Hence, based on (Hannum, Liu et al. 2014) results, food security is important for children at early stages of life before starting formal education.

(Gee 2018) confirmed this finding by investigating how kindergarteners cognitively developed in a family with an adult who experienced recurrent versus transitory food insecurity. A sample of 1,040 kindergarteners (mean age = 5.6 years) from the Early Childhood Longitudinal Study, Kindergarten Class of 2010-2011 was analysed using multilevel growth modelling. Results indicated that kindergarteners from homes with an adult who experienced recurrent food insecurity (twice within a 24-month period; $n = 490$) initially had slower growth in reading relative to their counterparts who were in homes with an adult who was food insecure only once over the same time period ($n = 550$). However, this initial disadvantage diminished over time. As a result, the recurrent group's reading trajectory converged with that of their transitory peers by second grade. These findings highlight the value of adopting more temporal view of food insecurity and its developmental consequences.

(Basch 2011), study's highlighted the negative effects of skipping breakfast on academic achievement and cognition in general. In his review, he listed a number of those negative effects according to the neuroscience researches. Skipping breakfast affects alertness, problem solving ability, attention, mathematical performance, and remembering process. Skipping breakfast is prevalent among the malnourished students. Food insecurity represented in skipping breakfast, negatively affects cognitive functioning with serious impact on essential cognitive process.

(Nkhoma, Duffy et al. 2013), investigated the differences in cognitive and nutritional status for entry-level schoolchildren in Malawi. The sample included 226 children aged 6-8 in two public primary schools in villages with similar socioeconomic, environmental and food pattern characteristics. One school was participating in national feeding program and the other not participating. Underweight and stunted growth were prevailing with insignificant differences between the schools. Results indicated insignificant differences in memory, attention, learning consequences, nutrition and cognitive performance for the two schools. Based on the results, the two schools equally required participation in food programs. Further, inclusive intervention and review of the food program participation are recommended. The above results may be attributed to the inefficiency of the applied feeding program. Emphasis should be placed on the application of comprehensive efficient feeding program to assure improved academic performance for children especially in case of physical developmental problems such as underweight and stunted growth.

(Lam and Lawlis 2017), reviewed 18 articles to test the effect of micronutrient interventions on cognitive performance of schoolchildren. They found a positive effect of micronutrients (vitamins and minerals) on fluid intelligence among children who suffer from micronutrients deficiency. The research review included experimental investigations, which indicated a causal relationship between nutritional factors and cognitive performance.

3. Psychosocial Factors and Cognitive Performance

In low income countries, school children and adolescents are suffering from different academic problems as a results of food insecurity. According to (Tamiru, Argaw et al. 2016), food insecurity is significantly associated with school absenteeism. Using cross-sectional data, they investigated a sample of 1000 students from primary schools from Jimma Zone in Ethiopia. They use a questionnaire to collect data about the following variables, food insecurity (includes poor dietary practices), economic status and socio-demographic information.

Findings showed that students from insecure household are 81% more absent from the schools compared to their peers from the secured household, especially female students. Results also showed that economic status has a significant role on food security, students from the household that have a livestock were less absent from schools compared to their peers from insecure households and have no livestock. Likewise, students from secured households headed by highly educated mothers are less absent from schools, compared to their peers from insecure household headed by less educated mothers. Hence, the research by (Tamiru, Argaw et al. 2016) proved the close association of school absenteeism with food insecurity especially for female students. Moreover, the negative influence of low economic status on food insecurity is higher for students from households headed by low educated mothers. School absenteeism is an important factor determining general academic performance. Sometimes academic performance, which is mainly cognitive affected indirectly by food insecurity, when the school children were absent frequently because of sickness (Edwards and Taub 2017), or when families are forced to delay the satisfaction of hunger because it is not a priority against housing and rent expenses (Ke and Ford-Jones 2015).

(Ahmad Bawadi, Saeed et al. 2015) estimated the spread of food insecurity among public school children in Jordan and its impact on academic performance, in addition to the prevalence of food insecurity according to sociodemographic characteristics. Data collected through questionnaire from a sample of male and female students, academic performance was measured by children's grades of the last year. Results indicated association of food security with student's gender, household income, and housing status. Food insecurity negatively influences children academic performance.

(Faight, Williams et al. 2017), assessed the relationship between food insecurity and academic achievement in school-aged children in Canada. The study was based on cross sectional data on parents and children. Parents, in addition to socioeconomic questions, completed the household food security module. The food frequency questionnaire was completed by children. Data were linked to the performance of children on standardized written

exams one year later. Based on results, very low household food insecurity is associated with poor academic achievement (in reading and mathematics) among children in Nova Scotia, as shown by Jyoti et al (2005). Food insecurity influenced basic academic skills such as reading and mathematics.

(Nanama and Frongillo 2012), considered the social and psychological experiences tightly attached to food insecurity in northern Burkina Faso where the region is characterized by subsistence farming, complex social structure, and chronic food insecurity. The study employed qualitative analysis using data obtained from questionnaire distributed to purposive sample, including the most seriously food insecure households, selected from two villages. Results obtained indicated that following socially unacceptable methods of coping with food insecurity (asking for food and borrowing) results in shame, which leads to, and is a signal of alienation. Under this situation, it will be harder for students to join schools. In addition, cognitive performance and academic achievements, for the students who managed to join schools are expected to be negatively affected by the unstable household conditions caused by food insecurity status.

(Jyoti, Frongillo et al. 2005), examined relations between household food insecurity and some of children's physical development, academic and social, measures over several years, using longitudinal design and modeling techniques which account for bias. The chosen developmental outcomes include reading and mathematics performances, body mass index (BMI), weight, and social skills. To measure household food insecurity USDA's Household Food Security Survey Module, was used. Direct assessments of reading ability and mathematics were followed individually in kindergarten and 3rd grade. Results indicated that food insecurity is related to specific developmental outcomes for both boys and girls, which may include nutritional and non-nutritional impacts. This includes damaged social skills and reading performance for girls. Based on the results food insecurity at kindergarten predicted poorer mathematics performance for girls, greater BMI and weight gains for girls. This result, emphasized (Hannum, Liu et al. 2014) results of the importance of food security at early stages of life for children.

(Howard 2011), estimated population-averaged applying subject-specific models for social skills scores of children determined by schoolteachers using longitudinal data on schoolchildren in the United States of America of both sexes from first, third and fifth grade during 1999-2003. Findings indicated significant negative contemporary and transitional relationship between food insecurity and social skills scores obtained by children. Based on research results, food insecurity affected children self-control, task persistence, and attentiveness, compared to engagement in aggressive classroom behavior, and interpersonal skills. The effect of food insecurity undermined effective classroom-based learning through hindered social skills development. According to (Howard 2011), the effectiveness of public

programs to improve food household food insecurity is questionable, where recent analysis related food insecurity to low consumption of healthy food, even for households receiving food aid. On the basis of (Aurino, Wolf et al. 2020) evidence from a Sub-Saharan African country, namely Ghana calls for attention to the necessity of multi-sectoral procedures encompassing nutrition and social protection to back up early child development.

The effects of social factors on food insecurity are multidimensional; the socioeconomic status is evident to be crucial because food insecurity occurs in low-income families. However, any interventions to improve the financial status will not be an effective solution when there is a presence of maternal and mental health problems indicating obvious connection between psychological and social factors, (Melchior, Caspi et al. 2009). The interaction between social and psychological factors associated with food insecurity is obvious in economic hardship, which is one of the Adverse Childhood Experiences (ACEs) (Food Research & Action Center, 2017). The impacts of (ACEs) may be traumatic, as the child suffers from hunger he/she may face self-esteem problems, gradually the child tends to withdraw from social life in school which may lead to poor academic performance.

4. Conclusions

Food insecurity affects cognitive performance of school children through two main factors, nutritional, and psychosocial factors. As the review has shown, special nutrients, such as vitamins, minerals, animal source proteins, play an important role in brain functioning of school children. The effect of nutrition appears in acting on molecular systems and the brain's ability to form and release its neurotransmitters. Skipping breakfast is frequent among malnourished students, so food insecurity represented in skipping breakfast, negatively affects cognitive functioning with serious impact on essential cognitive processes such as alertness, problem solving ability, attention, mathematical performance, and remembering. The negative impact of food insecurity on brain functioning will transmit to later cognitive performance and school achievement as shown in longitudinal studies. Inefficient feeding programs applied in some schools for the purpose of escaping food insecurity and mitigating the negative impacts on cognitive performance would have poor results. Consequently, emphasis should be placed on the implementation of inclusive efficient feeding program to assert improved academic achievement for children particularly in case of physical developmental difficulties such as underweight and stunted growth.

Evidence of negative impacts of low economic status on students was more observed on students from households headed by low educated mothers, reviewed articles signalized connection of food insecurity with student's

gender, household income, and housing status. Sometimes academic performance in reading and mathematics, affected indirectly by food insecurity, when the school children were absent frequently because of sickness, or when families are forced to delay the satisfaction of hunger because it is not a priority against housing and rent expenses. Moreover unstable household conditions caused by food insecurity affect academic achievements and cognitive abilities of students who managed to join schools, close negative impact was indicated for school absenteeism with food insecurity especially for female students. The efficiency of public programs to enhance household food insecurity is doubtful, where latest analysis related food insecurity to low consumption of healthy food, even for households benefiting from food aid programs.

The above screening showed that food security is of paramount importance for school children at all stages. The mental and physical consequences of food insecurity on human capital are expected to be of harmful impact on economic growth of nations. Based on the above review, improved cognitive capabilities for school children necessitates raising the levels of food security for poor and vulnerable households. Further, public programs for enhancing food security and improving economic growth of nations requires in depth focus on school children with special consideration on factors negatively affecting their food security, nutrition, and cognitive performance.

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