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The Cognitive Effects of Chronic Malnutrition and Environment on Working Memory and Executive Function in Children

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SIT Study Abroad

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Abstract

Chronic malnutrition, or stunting, occurs frequently in many developing countries such as Uganda. Stunting hinders physical growth and has been associated with delayed cognitive development, especially in young children. This study examined the effect of stunted growth on the function of cognitive processes involving the working memory and executive functions using neuropsychological assessments. Additionally, this study compared cognitive performances among rural and urban populations to analyze the environmental background differences which may affect cognition.

Population samples of fifteen five year old children classified as rural adequately nourished, rural stunted and urban adequately nourished were examined. Tests for working memory and executive control were employed including the digit span task, the Corsi Block task the Color Cancellation test and the FAS Phonemic Fluency test. Background information was collected for each participant including diet and health history.

Chronically malnourished children showed statistically significant deficits in selective attention, visual and auditory working memory and executive function compared to adequately nourished groups. Within the adequately nourished groups, urban and rural children showed statistically significant differences on tasks involving executive function, selective attention and visuospatial working memory. It can be inferred from the present study that stunted children have delayed development in the prefrontal cortex, causing impaired function of the working memory and executive function. The results also suggest that there may be other environmental factors that influence cognitive development in addition to adequate nutrition, which can have lasting effects on human development in Uganda.

1.0 Introduction

Undernutrition accounts for over one third of deaths in children under five world-wide, mainly due to increased susceptibility to disease. In Uganda specifically, 34% of children under five are stunted, 14% are underweight and 5% are wasted (UNICEF, 2015). Malnourishment impacts an individual's overall physical health with a suppressed immune system, increasing vulnerability to diseases such as malaria, typhoid and HIV. Malnutrition has been identified as a burden that mainly affects individuals in resource-constrained settings and has been thought to be an indicator of poverty (Caulfield, Richard, Rivera Musgrove and Black, 2006). The condition is furthered by biological vulnerabilities, inadequate resources and cultural influences, which further a child's vulnerability to disease and exacerbate the poverty cycle. In addressing human development, we need to understand the full consequences of the current status of child nutrition. Because so many children are affected by chronic malnourishment, it is important to study its effect on child development, especially with regards to the brain.

This study attempts to analyze the impact of chronic malnutrition, or stunting, on the dorsolateral prefrontal cortex, which controls the working memory function. By using cognitive assessments which reflect the visuospatial working memory, auditory working memory, selective attention and executive functions, we can compare the performances of children who are malnourished to adequately nourished control subjects. This study focuses on children of five years from the rural Namayumba sub-district of Wakiso and from an urban setting in Kampala. By comparing urban and rural children, we can understand the effects of environment and overall nutrition on a child's working memory function. Studying the working memory provides a good indication of overall cognitive potential and how the child will perform in school, influencing the long-term outcome of human capital. Because chronic malnutrition affects so many people, it is essential to understand the extent to which this burden hinders a nation's potential for growth and development.

1.1 Background

Undernutrition leads to growth failure through three main forms: acute malnutrition including wasting, chronic malnutrition including stunting, and general underweight which can include both acute and chronic malnutrition. Chronic malnutrition occurs gradually over time and generally results in a normal proportioned appearance, but shorter than appropriate for age. Stunting usually is caused by poor maternal nutrition, poor feeding practices and poor food quality early on in life, which lead to frequent infections that slow growth. In resource constrained environment, stunting can occur frequently as a child may be fed enough food, through starches and other affordable foods, but lacks a diverse diet with protein and other micronutrients needed for proper growth and development (Caulfield et al., 2006).

During the past decades, Uganda has made many efforts to address malnutrition and food insecurity. The Constitution of the Republic of Uganda (1995) pledged to ensure food and nutrition security for all Ugandans. In 2003 the Uganda Food and Nutritional Policy (UFNP) was adopted, which recognizes the human right to adequate food. The Nutrition Action Plan (2011) specifically aims at treatment and prevention of child malnutrition. This plan also falls in line with four of the Millennium Development Goals; Goal 1: Eradicate Hunger and Extreme Poverty, Goal 4: Reduce child mortality, Goal 5: Improve Maternal Health, and Goal 6: Combat HIV/AIDS, malaria and other diseases, which aim to address high rates of extreme poverty worldwide (United Nations, 2000). However even with these initiatives, Uganda will still fail to meet the Millennium Development Goal of halving the number of children underweight from 1990 by the end of 2015.

The crucial window for stunting occurs within the first 1000 days of for a child, from conception to 18 months of age (UNICEF, 2011). During this time period, children undergo the majority of their cognitive brain development. Stunting provides an indicator for insufficient physical development during the time period at which cognitive development is crucial. Poor early childhood nutrition has been associated with structural and functional impairments to the brain, as well as permanent cognitive effects (Dewey and Begum, 2011). These impairments affect a child’s ability to learn, impacting school performance and reducing a child’s potential for achievement. Children with learning impairments will have additional difficulties completing their education and will cause a reduction of human capital and lower the potential productivity of the nation (Appendix A). Chronic malnutrition carries across generations, beginning with a malnourished mother who produces a child already malnourished at birth. This cycle often parallels the poverty cycle and continues to burden families with a reduced potential for achievement.

The prefrontal region of the brain is responsible for the executive functions and the working memory as well as higher order cognitive tasks and attention, which are very relevant indicators for an individual's capacity to learn. The working memory is most often referred to as short term memory or "mental workspace" of the mind. It is the area of the brain responsible for complex cognitive processing such as reading, arithmetic, and concentration during learning. The working memory is mediated by the phonological loop, visuospatial sketchpad and the central executive functions within the prefrontal cortex (Baddeley and Hitch, 1974). Because the working memory is essential to concentration and higher order processing of information, it is very relevant to predicting a child's ability to learn and succeed in school. People with working memory impairments have poor attention spans and have difficulties with complex cognitive tasks (Kane and Engle, 2002). Damage to the development of the working memory can thus impact children's school performance, putting them at an academic disadvantage, which in a resource-constrained area can make literacy unachievable.

Study Setting:

Peak Kindergarten is a faith-based private Nursery School located in Ntinda, Kampala. The school holds over 200 students ranging from baby class to top class. The school uses updated curriculum, and many children complete with academic performance above what is needed for Primary-one. The school uses only English and children come from diverse areas of Kampala. The school is considered to be a high-grade Nursery school and school fees are more expensive, indicating that the majority of parents come from an affluent background. Namayumba is a sub-county of Wakiso District in the Central Region of Uganda. The community is located in a rural setting, and most of the population farms for their income. In the Central Region, 39% of children are considered stunted, with 15% severely stunted (ORC Macro, 2006). Namayumba has a Health Center IV which includes a pediatric unit that specializes in treating acute malnutrition. It is staffed with once doctor, a clinical officer, many nurses and a nutritionist. The Namayumba Health Center IV receives many patients everyday who are referred from other Health Centers in the area. Although the facility is the largest health center in the surrounding area, it is often limited by a lack of staff and supplies which run out frequently.

1.2 Statement of the Problem

Because chronic malnutrition has such a large impact on Uganda's population, the effects on cognitive development may have serious implications for the human development of the country as a whole. A reduced cognitive capacity hinders the ability to learn, thus preventing individuals from reaching their full educational potential. In an already resource-constrained setting which reflects many malnourished communities, the optimal use of human capital is diminished, which impairs development as a whole.

1.3 Objectives

-To establish a relationship between malnourishment and cognitive abilities in young children, using cognitive assessments to test verbal and auditory working memory, attention and executive functions.

-To compare cognitive and developmental background differences among children in rural and urban settings.

-To examine the social, environmental and cultural context of stunted rural populations, by using the Namayumba sub district as a case study.

-To analyze the impacts of malnutrition on cognitive function in the greater context of Uganda and human development.

1.4 Justification

Because stunting occurs in such a large portion of the population in Uganda, it is crucial that we understand the effects of malnutrition on the ability to learn. Children with cognitive deficits will be unable to reach their full potential as adults, impacting the productivity and human capital of the population, which hinders development. Additionally, a child with cognitive impairments due to undernutrition will be less likely to finish schooling, placing them at economic disadvantage, further perpetuating the poverty cycle. In order to properly address malnutrition, we need to understand the immediate as well as the lasting effects. This study helps to provide an insight to the long-term consequences of chronic malnutrition, which further emphasizes the importance of addressing this condition, which is so often overlooked in the wake of acute malnutrition.

I chose to compare normal children with chronically malnourished to provide a reference for my data analysis. After realizing the large differences between children in the rural environment and children in the urban setting, a control group from Kampala was chosen to compare. At five years old, a child has reached the end of the crucial development phase, yet has not formally begun school yet. Participants at age five will have the skills needed to complete these cognitive tasks, but will not be fully influenced by their educational environment.

2.0 Literature Review

Sally Grantham-McGregor published a review article (1995) which established the relationship between malnutrition and mental development, identified as lower IQ, cognitive function, and school achievement. The article discusses the impact of a child's environment in addition to malnutrition having an impact on cognitive development and possible causation to the correlation identified. The MAL-ED Study (2014) provided a multidisciplinary longitudinal study on malnutrition, gut physiology, the immune response, cognitive development and physical growth in young children in resource poor environments. This study emphasized the importance of nutrition for cognitive development, marking a noticeable difference in children over time. They used surveillance of feeding practices, blood samples, monitoring growth with anthropometric indices and conducted infant cognitive assessments measuring language skills, stimulation, temperament, and learning capacity. The study was carried out in six countries suffering from high prevalence of malnourishment at eight sites, resulting in 800 participants. The study showed the intricacies entailed in the effects of malnutrition, which thus requires a focus on a crucial time period for development in gaining maximal impact for cognitive development in a resource constrained setting.

Other studies focused on the effects of concurrent stunting during early childhood (Crookston et al., 2011), testing cognitive abilities in preschool age children (ages 4-6). This study compared adequately nourished children with malnourished children, and additionally accounted for the interventions of attending a pre-school and other external environmental factors which may impact cognitive development. Although attending a pre-primary school did impact a child's cognitive development, suggesting that cognition can be improved with adequate stimulation, the biggest factor affecting a child's cognitive capacity involved the level of nutrition he or she received.

Another study tested the prefrontal cortex effects of pre-natal malnourishment in rats (McGaughy et al. 2014). The rats were depleted of glucose and additional proteins in utero, considered to replicate the conditions of a malnourished child. After preforming general cognitive tests on the rat such as simple discrimination or tests for attention, the rats were anesthetized and brains were removed for analysis. Results indicated a lower cognitive flexibility in tests for the malnourished group and brain imaging indicated significantly less development in the prefrontal region of the brain.

One study conducted in India studied protein energy malnutrition in young school children and the effects on cognition and motor abilities (Kar, Rao and Chandramouli, 2008). This study also included different ages for testing, which could be beneficial to analyzing crucial benchmarks in learning, but distracts from the focus of looking at one specific age group. The results suggest that malnourished children may have decreased development in higher cognitive processes, including those needed for attention, visuospatial ability and learning located under working memory within the prefrontal cortex.

3.0 Methods

Participants:

The study consists of three sample populations: adequately nourished urban, adequately nourished rural and chronically malnourished rural children. Each sample consisted of 15 children at the age of five years (5:0-5:11) within the central region of Uganda. The populations were all enrolled in pre-primary school. Children with current illness, noticeable mental impairment or pre-existing neurological disease were excluded. Additionally within the adequately nourished groups, children considered wasted by Mid-Upper Arm Circumference (MUAC) measurement were excluded from the study.

Urban:

Children were recruited from Peak Kindergarten in Ntinda, Kampala from both middle and top classes. The headmistress helped to identify 15 children at 5 years using a sampling of children who were picked up by their parents. After children of 5 years were identified by the headmistress and teachers, the researcher enrolled participants in the study as parents came to pick up their children from school. Parents were given a consent form and introduced to the study by the researcher and school counselor, during which time they also filled out the parent questionnaire.

Rural:

Children were recruited from the Namayumba sub-county, Wakiso District using simple random sampling of children at 5 years. Using contacts from Namayumba Health Center IV and VHTs the researcher identified areas with high populations of children and moved from home to home in the villages looking for participants. VHTs helped to locate some families with eligible participants, but the majority of the participants were recruited by random encounter through the village. Participants came from the Namayumba trading center and surrounding villages. After the child’s age was identified, the child was measured and classified as adequately nourished (n=15) or stunted (n=15). Parents were given a consent form and questionnaire in the local language, Luganda, and a translator was used to administer both forms as well as to conduct the cognitive tests.

Anthropometric Measurements:

The height, weight and MUAC were recorded for each child to determine nutritional status and measure development. Height was taken using a UNICEF infant/child standing height board and weight was taken using a UNICEF digital weighing scale manufactured by SECA. Height-for-age z-scores for each gender based on the international reference standard from the World Health Organization (WHO, 1983) were used to classify stunted children. Stunted children were defined as those with a height-for-age z-score of below -2.0 standard deviations below the median. The MUAC tape was used to identify acute malnourishment within the field, to exclude participants if necessary. Additionally, WHO reference standards were used to analyze weight-for-height (BMI) z-scores to determine if a child was wasted and weight-for-age z-scores to determine if a child was considered underweight, based on the same cut-offs used for stunting. If a child was identified as wasted, the researcher informed the local VHT who referred the family to the Namayumba Health Center IV Nutrition Unit.

Parent Questionnaire:

A parent questionnaire was given to the caregiver of participants in order to establish a background on the child's health history and nutritional status during the first years of development. Questions were included about the child's infancy and antenatal care, previous illnesses and diet during the first three years of life (Appendix B and C).

Cognitive Testing:

Cognitive tests were administered in a comfortable setting for the child. In the Urban setting, testing occurred at a table in the school library with the presence of a school counselor. In the rural setting, tests were administered at the home, either inside or outside, on a mat or at a bench depending on the child's normal environment. During the assessment, the researcher, translator and a parent were present, often including the participant's siblings who watched quietly. For both settings, the testing environment was quiet with minimal distractions present. Four tests were given to each participant in order to assess the child's selective attention, visuospatial working memory, auditory working memory and Phonemic Fluency, which are mediated by the pre-frontal cortex.

Color Cancellation Test (Kapur, 1974): This test was used to measure a child's selective attention and central executive processes. The participant was given a sheet with 150 circles of 5 different colors: red, yellow, black, blue, and gray (Appendix F). The participant was given a pencil and asked to point to the red and yellow circles. After verifying that they could distinguish colors, the participant was asked to cross out only the red and yellow circles as quickly as they could, and shown an example for each color. The child was then instructed to inform the researcher when they thought they had finished. Time taken to complete the task was measured with a stopwatch and the number of omissions (red and yellow circles left blank) were recorded.

Digit Span Task (Turner and Risdale, 2004): The digit span task was used to measure the auditory working memory capacity. The participant was asked to repeat the numbers the researcher articulated. Beginning with two digits, two trials were given for each digit span and after two successful completions the researcher increased the sequence by one digit, until reaching a maximum of nine. If one trial failed, the participant was given an additional third trial to account for simple errors. After two failures within one digit span the test was stopped. The total number of correct responses comprised the score. (Appendix G) The test was then repeated, but instead the participant was asked to repeat the digits backwards. The concept of backwards was explained to each participant using examples and visual representations before beginning the test.

Corsi Block Test (Kesseld, van Zandvoort, Postma, Kappelle and de Haan, 2000): The Corsi block task was used to measure the visuo-spatial working memory capacity. The participant was presented with nine blocks arranged in a clustered fashion and was asked to repeat the researcher's movements. Beginning with two blocks, the researcher tapped each once and then asked the participant to repeat. After two successful trials for each set, the number of blocks tapped was increased until reaching a total of nine blocks. If one trial was failed, the participant was given an additional third trial to account for simple errors. After two failures within one set, the test was stopped. The blocks tapped were given in the same order as the digit span task with a visual equivalent to each number. The test was then repeated in the backwards form and the participant was asked to tap the sequence in the reverse order. The child was given multiple practice trials after the concept of backwards was explained. The total number of correct responses comprised the score.

FAS Phonemic Fluency Test (Lezak, 1995): The Phonemic Fluency Test was used to assess central executive functions as well as verbal fluency. The participants were asked to produce as many words they could think of beginning with a certain sound (F, A, S or Ma, Ok, Mu) in one minute (Appendix H). A separate set of sounds was used as a Luganda equivalent in the rural setting to substitute for F, A, and S. Words produced cannot be repeated or begin with the same stem (ie. walking and walked). The researcher recorded all the words produced by the participant. After each minute, the next sound was presented and the sum of all the words produced during the three trials comprised the total score.

Qualitative Methods:

The researcher also utilized participant observation to ground the study in a deeper understanding of health care in the Namayumba community. The researcher stayed with a nurse living on the Health Center property and watched the interactions between the health center and the community. The researcher assisted with taking measurements and blood pressure for patients during three mornings, and attended two community outreaches with VHTs in which vitamins were distributed, diabetes screenings and educational sessions occurred.

Statistical Analysis:

All data was analyzed using SPSS Statistical Software Version 20 (IBM, 2011). Categorical variables from survey data were analyzed using Pearson's Chi-Squared test for association. One-way ANOVA was used for the digit span tests and the FAS Phonemic Fluency assessment. One-way MANOVA was used for the Color Cancellation Test using the total time taken and number of omissions. Results were analyzed using Tukey's Post-Hoc Analysis to compare differences between subject groups for the assessments. Significance was defined at a $p< .05$ for all analysis.

Limitations:

There were a few limitations to the methodology which affected data collection. The first of these was the limited time frame of the six week study project, which prevented the researcher from exploring additional variables. Because of this limited time, the study captures only one time point for these children and cannot offer any longitudinal perspectives. Within the village, many of the children whom the researcher came across that would have been considered stunted did not have parents around to obtain consent. Most of them were off working in the gardens because it was the rainy season. It was difficult to find children at exactly 5 years because the Ugandan concept of age is different within the village. Instead, the age had to be estimated based on child's birth year and time markers such as the rainy and dry season, holidays, and important events that occurred during that year. Lastly, the study design of the parent survey gave limited information and needed to be made more specific to definitively compare between subject groups.

Ethical Concerns:

The main ethical concern of this study was the risk in dealing with children, a vulnerable population. Because the study was focused on child subjects, extra caution was used to ensure safety of children and protection of their rights. These concerns were addressed by obtaining informed consent from parents, ensuring tests caused no more than minimal harm and keeping the best interest of the children in mind at all time.

The informed consent explained the purpose of the study, as well as the risks and benefits involved. Although there was minimal risk associated, the children were required to participate in the study for about 30 minutes which may have been considered inconvenient. The indirect benefits of the study included educational psycho-stimulation and a better understanding of nutritional effects on learning, which will benefit public health in Uganda and development as a whole. A list of rights for the child were also provided during the study including IRB contact information. The consent form was provided in the parent's native language, and the translator read the consent for the parent if they couldn't read. Along with parental support, an objective observer was present during the assessment to ensure that the child did not feel coerced at any time. Verbal consent was required from the child participants, and the researcher made sure they understood procedures before beginning each test during the assessment.

The tests were age appropriate for children and are designed to be interactive and maintain attention. During the test if the child needed a break, one was given to maintain accuracy of results. Within the Urban setting, the headmistress of Peak Kindergarten was notified of all aspects of the study and of any concerns during testing. Within the rural setting, a translator gave instructions in the child's native language, and a caretaker was present during the assessment.

Lastly, within the Namayumba community the researcher had to understand cultural norms when obtaining consent and built a rapport with community members before beginning assessments. Because of the researcher's position as an outsider to the culture, they were presented to participants by someone whom the child knew and was comfortable with. Compensation was given to the translator and VHT's for assisting with research.

In order to maintain compliance with IRB standards and ethics, all data was de-identified to protect personal health information. Participants were given an identification number which was used to maintain anonymity of responses.

4.0 Data and Findings

Participant Characteristics:

Each sample consisted of 15 participants, all of which were 5 years of age, attended Nursery school and all received antenatal care. Within the Rural adequately nourished and Urban adequately nourished groups, none of the participants showed signs of wasting or being underweight. Within the Rural stunted group, five of the participants were considered underweight (33.3%) and one was considered wasted (6.7%). Table 1 shows the health characteristics of the participants by classification. Statistically significant differences were found using Pearson's Chi-Squared test for Association within the child's birth setting (p=.008) and previous illness (p=.004) categories. Table 2 represents the weekly diet of participants during the first three years of life by classification. Statistically significant differences were found within the meat (p=.001), other protein (p=.002), and vegetable (p=.002) intake.

Table 1: Characteristics of Study Participants by Classification

Independent Variable	**Rural Stunted**	**Rural Adequately Nourished**	**Urban Adequately Nourished**	***P*-Value**
N	15	15	15	
Sex (%)				.913
Male	40.0	40.0	46.7	
Female	60.0	60.0	53.3	
Birth Setting (%)				.008*
Government Hospital	86.7	60.0	26.7	
HC II or III	0	6.7	0	
Private Hospital	6.7	26.7	73.3	
TBA	6.7	0	0	
Other	0	6.7	0	
Months Breastfed (%)				.308
Less than 6	0	0	6.7	
7-12	13.3	33.3	46.7	
13-18	40.0	20.0	26.7	
19-24	46.7	40	20.0	
24+	0	6.7	0	
Illness (%)				.014*
None	20.0	0	53.3	
Malaria	66.7	100.0	46.7	
Sickle-cell Anemia	6.7	0	0	
HIV	6.7	0	0	

*. Pearson Chi-Square test for association is significant at the 0.05 level.

The table above represents the distribution of demographic characteristics among group classifications including gender, the participant's birth setting, the number of months breastfed and illnesses during the child's first three years of life. Pearson's Chi-squared test for association was used to determine significance between groups as shown on the right.

Table 2: Diet during First Three Years by Classification

Independent Variable (Number of times per week)	**Rural Stunted**	**Rural Adequately Nourished**	**Urban Adequately Nourished**	***P*-Value**
N	15	15	15	
Starch (%)				.177
1-2	6.7	0	6.7	
3-5	20.0	13.3	46.7	
6 or more	73.3	86.7	46.7	
Meat (%)				.001*
Never	40.0	46.7	0	
1-2	60.0	46.7	40.0	
3-5	0	6.7	46.7	
6 or more	0	0	13.3	
Other Protein (%)				.002*
Never	20.0	6.7	0	
1-2	46.7	33.3	0	
3-5	33.3	33.3	33.3	
6 or more	0	26.7	66.7	
Vegetables (%)				.002*
Never	26.7	0	0	
1-2	46.7	40.0	6.7	
3-5	26.7	20.0	53.3	
6 or more	0	40.0	40.0	
Fruit (%)				.170
Never	6.7	0	0	
1-2	0	26.7	20.0	
3-5	80.0	60.0	46.7	
6 or more	13.3	13.3	33.3	

*. Pearson Chi-Square test for association is significant at the 0.05 level.

The table above represents the distribution of diet including number of starches, meat, other protein, vegetables and fruit per week during the child's first three years of life. Pearson's Chi-squared test for association was used to determine significance between groups as shown on the right.

Cognitive Assessments:

Table 3 shows a comparison of assessment scores between subject groups. For the digit span tests (Figure A), significant differences were found in all assessments between the stunted group and the two adequately nourished group ($p<.05$). However, between the urban and rural adequately nourished groups, significant differences were only found with the digit backwards (p=.000), block forwards (p=.035) and block backwards (p=.005) assessments. For the FAS phonemic Fluency test (Figure B), significant differences in scores were found between both stunted and adequately nourished groups, and urban and rural groups. Lastly for the Color Cancellation Test (Figure C) significant differences in total score, accounting for number of omissions and total time taken were found between both stunted and adequately nourished groups, and urban and rural groups. However, there was not a significant difference in number of omissions between urban adequately nourished and rural adequately nourished groups (p=.898).

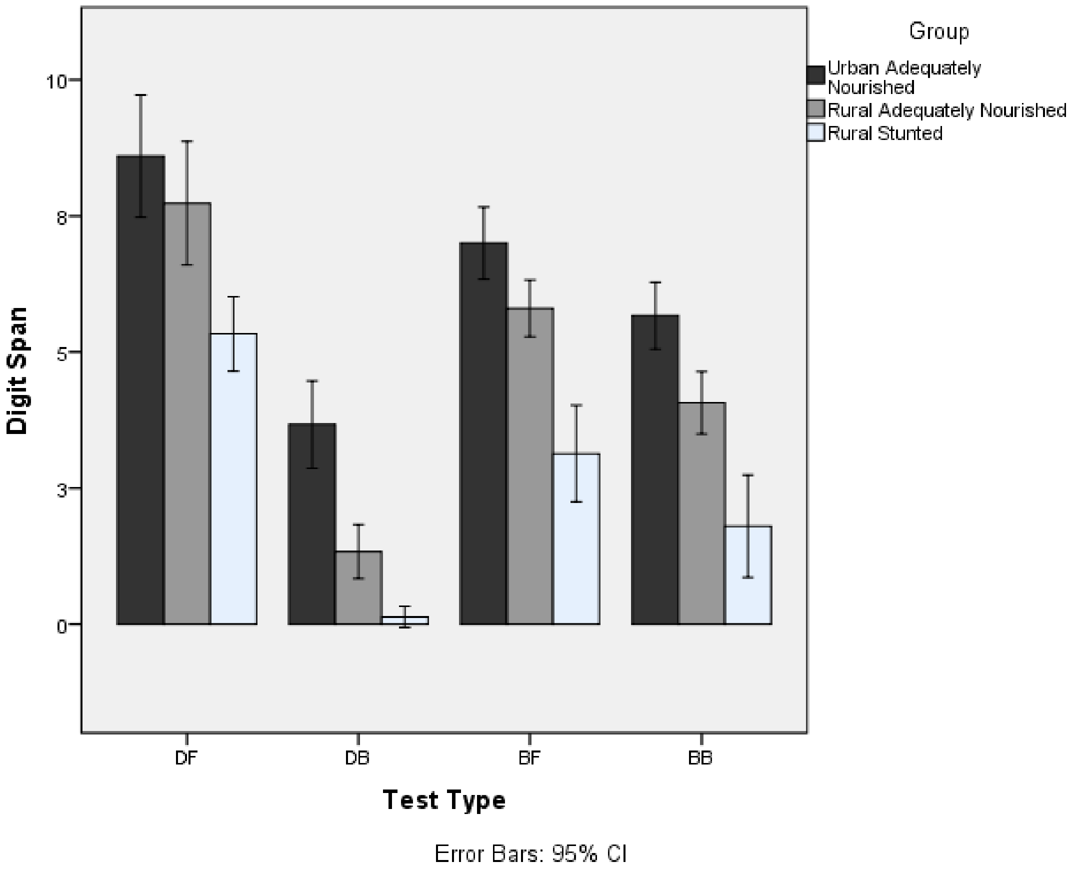


Figure A: Digit Span Tests. The figure above shows the average scores for the Digit Forwards (DF), Digit Backwards (DB), Block Forwards (BF) and Block Backwards (BB) assessments for each subject group. Error bars show the 95% CI for each mean. Significance was identified using ANOVA analysis

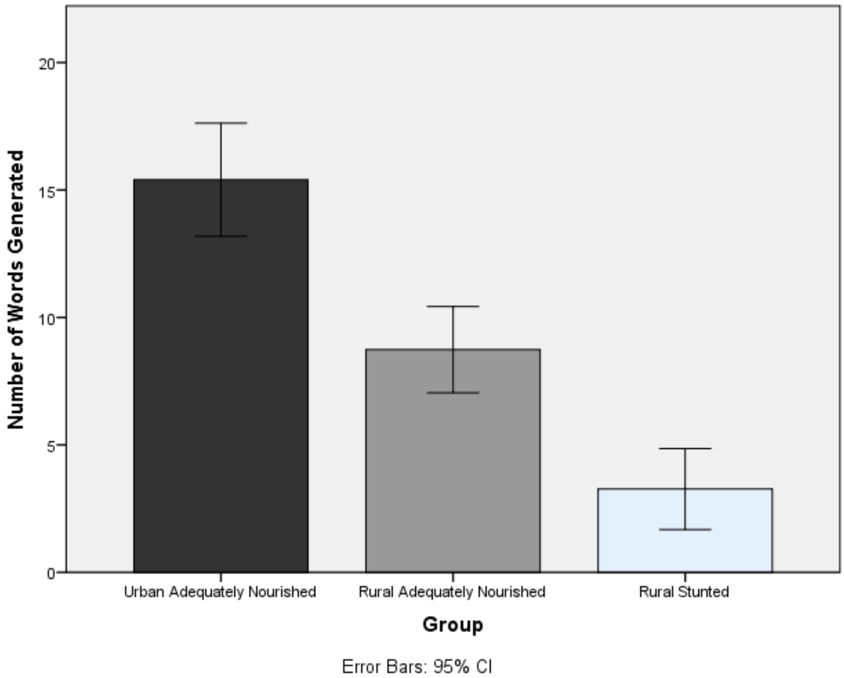


Figure B: FAS Phonemic Fluency Scores. The figure above shows the average number of words generated in the FAS Phonemic Fluency Test for each group. Error bars indicate 95% CI for each mean. Significance was identified using ANOVA analysis.

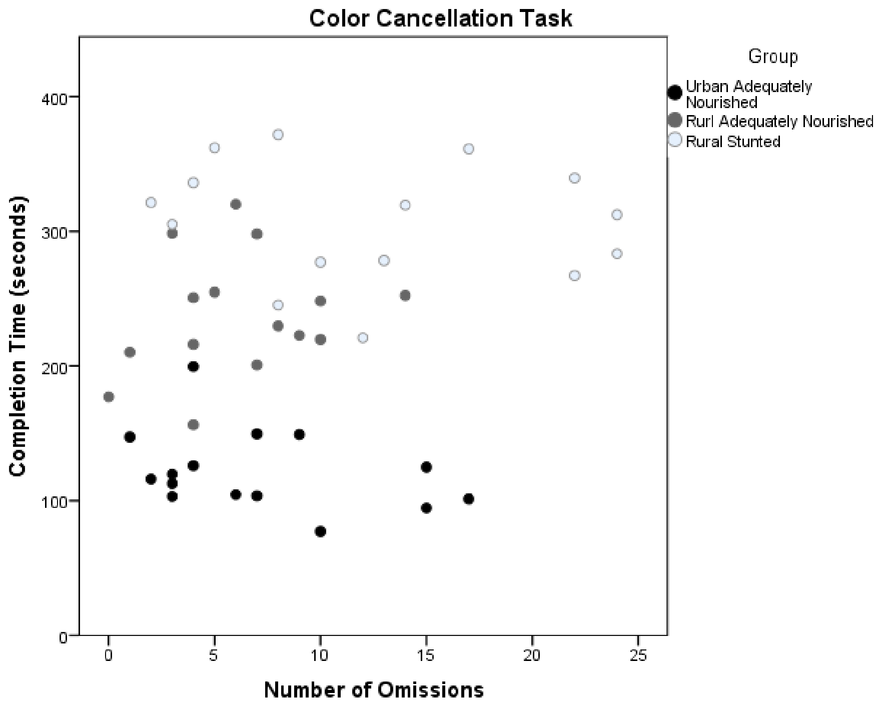


Figure C: Color Cancellation Test. The scatter plot above represents the overall score of the color cancellation task including the completion time and number of omissions for each subject group. Urban adequately children reflected the lowest scores with lower numbers of omissions and shorter completion time. Rural stunted children reflected higher scores with a greater number of omissions and longer completion time taken. MANOVA was used to identify a significant difference between subject groups with a Wilk's Lambda value of .000.

Table 3: Comparison of Assessment Scores between Groups

Test Type	(I) Group	(J) Group	Mean Difference (I-J)	Sig.
Digit-For	Urban Adequately Nourished	Rural Adequately Nourished	.867	.398
		Rural Stunted	3.267*	.000*
	Rural Adequately Nourished	Rural Stunted	2.400*	.002*
Digit-Back	Urban Adequately Nourished	Rural Adequately Nourished	2.333*	.000*
		Rural Stunted	3.533*	.000*
	Rural Adequately Nourished	Rural Stunted	1.200*	.006*
Block-For	Urban Adequately Nourished	Rural Adequately Nourished	1.200*	.035*
		Rural Stunted	3.867*	.000*
	Rural Adequately Nourished	Rural Stunted	2.667*	.000*
Block-Back	Urban Adequately Nourished	Rural Adequately Nourished	1.600*	.005*
		Rural Stunted	3.867*	.000*
	Rural Adequately Nourished	Rural Stunted	2.267*	.000*
FAS	Urban Adequately Nourished	Rural Adequately Nourished	6.667*	.000*
		Rural Stunted	12.133*	.000*
	Rural Adequately Nourished	Rural Stunted	5.467*	.000*
CC- time	Urban Adequately Nourished	Rural Adequately Nourished	-115.0807*	.000*
		Rural Stunted	-184.8067*	.000*
	Rural Adequately Nourished	Rural Stunted	-69.7260*	.000*
CC- omission	Urban Adequately Nourished	Rural Adequately Nourished	.93	.898
		Rural Stunted	-5.47*	.035*
	Rural Adequately Nourished	Rural Stunted	-6.40*	.011*

*. The mean difference is significant at the 0.05 level.

The table above represents the mean differences in scores between subject groups. Tukey's Post-Hoc Analysis was used to identify a significance in scores between groups for each assessment as shown on the right. ANOVA was used for Block forward, Block Backward, Digit Forward, Digit Backward and FAS Phonemic Fluency assessments. One-way MANOVA was used for the color cancellation tests.

5.0 Discussion

The findings from this study help to locate the cognitive effects of chronic malnourishment to the prefrontal cortex, the area of the brain responsible for executive functions and the working memory, and compare differences among children in rural and urban settings. The results confirmed that chronic malnourishment does impair performance on cognitive tasks involving the working memory and executive control. The study additionally found differences among adequately nourished children in rural and urban settings, comparing participants' background and assessment performances. The present study locates this issue within Uganda, as a means to further emphasize the importance of addressing chronic malnourishment and the factors which cause stunting in children.

Effect of Malnutrition on Cognitive Development

Selective Attention and Executive Control

The rural stunted group preformed significantly worse on the color cancellation test than the rural adequately nourished and urban adequately nourished subject groups, taking longer to completely the task and leaving more omissions. This indicates poorer selective attention, which is mediated by the prefrontal cortex. Selective attention requires the central executive part of the working memory to maintain focus when presented with distracting stimuli. This level of cognitive control would be lessened in an underdeveloped pre-frontal cortex, thus explaining the poorer performance on tasks requiring selective attention. Chronically malnourished children also showed poorer Phonemic Fluency scores compared to adequately nourished children. The ability to retrieve and produce words of similar sounds is controlled by the central executive and is required for higher order cognitive processes.

Working Memory

Chronically malnourished children showed poorer performance on working memory tasks compared to adequately nourished children. The digit span task indicates an individual's auditory working memory mediated through the phonological loop. The poorer performance in the corsi block test suggest poorer functioning working memory through the visuospatial sketchpad, which is the ability to assess and hold information in the short-term visually. The backwards tasks additionally measures and individual's cognitive flexibility and higher order processing through the central executive (Baddeley and Hitch, 1974). Both working memory tasks are mediated through the dorsolateral prefrontal cortex and delayed cognitive development of this region could account for the observed differences in cognitive performance between stunted and adequately nourished children.

The working memory capacity reflects the overall efficacy of executive functions, allowing an individual to focus and maintain attention. Because of its localization within the prefrontal region, working memory capacity appears to be a major driving force of cognitive development, especially relevant in children (Kane and Engle, 2002). This may suggest that impairments to the working memory could have adverse outcomes for learning and educational achievement in children.

The differences in cognitive performance between malnourished children and adequately nourished children are consistent with previous studies, which identified deficits in working memory, selective attention and verbal fluency (Kar et al., 2008). Although the exact mechanism is still unknown, chronic malnourishment at a young age alters cognitive development, impacting the functioning of the prefrontal cortex. Nutrition is crucial to growth, and thus a deprivation of necessary nutrients can force the body to compensate in order to survive, as indicated by stunting. Stunting slows the rate of cognitive development, but some studies have shown that improvements in cognition can occur over time (Crookston et al., 2011). These children however are placed at a disadvantage to their peers and cognitive deficits during school years can inhibit children’s achievement during the most crucial time for education. Children who are stunted early in life have poorer performance in school, lower IQ scores and more behavioral problems which can last through adolescence (Grantham-McGregor, 1995). Some higher order cognitive processes of the brain including executive functions and visuospatial processing may be more difficult to recover over time and thus delay development during childhood years even further. These disadvantages could already be seen in the stunted children who were often still in baby class because they were not ready to move on to the next level.

The cognitive deficits that occur in stunted children could be related to the delay in the development of structures and overall functional maturation, such as reduced development of dendritic spines or delayed myelination within the developing brain (McGaughy et al., 2014). Such impairments would reduce the formation of synapses and thus reduce the functionality and performance of areas of the brain necessary for higher cognitive processes.

To look at it another way, if a car is running low on fuel, the driver of the car will turn off the air conditioning and any non-essential processes in order to save fuel. The driver will take the shortest route to the gas station and will not make as many changes in speed or gear shifts, which will waste fuel. In a situation where the body is not receiving enough nutrients, it must simplify its processes in order to retain energy. Thus only essential functions are maintained, such as motor control and breathing, placing cognitive growth and development on hold. This mechanism for survival however impacts the ability to learn and process information, preventing children from reaching their full cognitive capacity and opportunities for human capital development.

Cognitive Differences among Rural and Urban Children

In addition to differences in performance between adequately nourished children and stunted children, adequately nourished rural children also performed significantly lower on tests of verbal fluency, selective attention and executive functions in the backwards tasks compared to the urban adequately nourished children. Although there was little difference in the auditory working memory and number of omissions during the color cancellation, the rural children had slower reaction times to timed tasks.

These results could indicate that children in the Namayumba community, although considered adequately nourished by anthropometric standards, lack the diverse diet needed for optimal cognitive functioning to the extent of the urban subjects. The results could also indicate additional factors, other than nutrition may impact a child's cognitive performance, such as psychosocial stimulation, educational background, previous illnesses, or overall environment.

Background Differences

The socioeconomic difference between the children attending Peak Kindergarten and the Namayumba community plays into the environmental setting which may have impacted the children's performances. In the Namayumba community, the majority of families are farmers and spend most of their days working in the gardens in order to provide for their children. This work can be very time consuming and labor intensive, taking much attention from young children. In many of the families from which participants were enrolled, the parents lacked an educational background past primary school, and very few could afford toys for their children. Children in the rural environments lacked early childhood stimulation and educational background in the home that could be gained from interacting with parents and playing with educational toys outside of the nursery environment. Most children from Peak Kindergarten had parents who had completed higher education and were able to afford educational resources for the home environment.

The background differences as shown in the health history and diet may also provide insight to the observed differences in performance. Rural children consumed more starches and less meat, other proteins, or vegetables than the urban children. These nutritional differences could be due to cultural differences in diet, but are mainly caused by socioeconomic status. Starches are affordable and easily available in the villages, making posho and porridge a staple to the diet. However, meat and other foods may be more expensive and harder to access in a rural setting in order for one to maintain a diverse diet. The urban setting has greater access to a variety of foods which are more affordable for those in a higher socioeconomic class. The birth setting additionally may be accounted for by accessibility in rural and urban environments. Lastly, the differences in early childhood illness, especially with regards to malaria prevalence may have an impact on a child's cognitive development. The higher prevalence may be due to a higher mosquito incidence in the village setting, or due to differences in use of malaria prevention strategies such as bed nets or fumigation.

Cultural Influence:

Although the assessments were meant to be used in any type of cultural setting and presented in the child's spoken language, the foreign nature of some of the assessment items may have impacted the results between the rural and urban subjects. Participants in the rural groups may have struggled with the concept of "backwards", which may not be referred to often within the community. Most of the urban children caught on very quickly to the concept, whereas the rural children required a more in-depth explanation, thus lack of familiarity led to poorer performance. The color cancellation test was also unusual to the children in Namayumba, who were not accustomed to seeing colors on a sheet of paper. The children could distinguish colors, but may not have known their names or how to identify the colors on the sheet, possibly impacting their reaction time during the tasks. Additionally the blocks used in the Corsi block test may have been unfamiliar to children who have never played with educational materials such as blocks which are not readily available in the community.

The appearance of the researcher may have been more unfamiliar to the rural participants whom many had never seen a person of a different race before. For the urban children, the researcher was different to them but not necessarily foreign or scary. However, in the rural setting, some of the children were confused or intimidated by the presence of a "Muzungu" or white person. The difference in perceptions of the researcher may have impacted the child's performance on the tests.

All of the participants were enrolled in various levels of Nursery school, however the large difference in assessment performance suggests an imbalance in the baseline education received in rural and urban settings. The assessments given should not require an educational background, but during the tests all the subject groups seemed to rely heavily on what they had learned in school in order to help them. Therefore, performance on the phonemic fluency test may have been affected, especially if the child attended a Nursery school that taught in English rather than Luganda. Rural children had difficulties applying their educational skills to their local language, unless they attended a school that instructed in Luganda. This presents an interesting finding and application to the educational field as many Ugandan children must change the language of learning to English during the middle of primary school. The assessment results suggest that the rural children may already be at an academic disadvantage before primary school even begins.

Study limitations:

Because schools were on term break at the time of the research, rural participants had to be tested from the home rather than at the school. This may have impacted their performance as they may not be used to academic or educational environments in their home setting. Often the testing conditions were subject to environmental influences such as heavy rain, confined spaces or external noises. Although many of the noise distractions also occurred in the urban setting, the testing environment was easier to control.

The parent surveys were designed to give a general picture of the child's background but may have failed to identify certain correlations between malnourished children and adequately nourished children. The question about breastfeeding may have yielded insignificant results because it did not distinguish between exclusive breastfeeding and complimentary breastfeeding. Understanding how long the mother did each may have presented a clearer picture of the child's nutritional background. Additionally, the questions about food groups was beneficial for identifying differences in general diet, but may have yielded more concrete findings if questions were targeted towards food frequency, amount, quality, hygiene and variety of the child's diet. Despite these limitations, the study had many strengths in the ability to avoid confounding variables such as wasting, neurological impairment or current illness as noted in the exclusion criteria. Additionally, the researcher was able to adapt the assessments to an appropriate environment before beginning with a pre-test in both the urban and rural settings.

The study results indicate a relationship between chronic malnutrition and cognitive impairment, localized to the prefrontal cortex. The poorer performance among rural adequately nourished children compared to urban adequately nourished children indicates that there may additionally be a relationship between cognitive performance and the environment in which the child is raised. The study additionally identified some nutritional and early childhood factors that may characterize chronically malnourished children. Using these results we can better ground future studies on cognition and children in the context of Uganda.

6.0 Recommendations

Within the health community, much of the attention falls on acute malnutrition in children, which requires urgent care and can cause death. Stunting occurs over a long period of insufficient nutrition and thus can go unnoticed without the obvious signs of acute malnourishment such as low weight, edema, and wasting. Although it takes a long time to see its effects, it is crucial to address stunting in order to prevent developmental delays. Both acute malnutrition and chronic malnutrition can be prevented using the same approach, but stunting lacks appropriate treatment strategies that are present with acute malnutrition. Children who are stunted may have many developmental delays that require attention in order to help the child catch up to age-appropriate development milestones. However, health facilities are not equipped to handle such child-development concerns and additionally do very little to follow up on the child's nutrition if they are identified as stunted, such as done with the acute malnourishment rehabilitation programs and follow-ups.

Central Government

- Strengthen Health Info Management System
- Ensure that health workers are using a holistic approach with health screening by including height and MUAC in addition to weight for each child using updated IYCF guidelines
- Require Health facilities to regularly plot child's growth through first five years to ensure proper development and notice warning signs.
- Scale-up on programs such as ANI by the WHO
    - Support programs to promote complementary feeding
    - Research and provide local food-based data recommendations
- Add nutritional education to standard school curriculum
- Create nutrition awareness campaigns similar to the HIV and TB campaigns
    - Target both men and women; a child's nutrition is the whole family's responsibility
- Cascade capacity building
    - Strengthen support an effective supervision to the district and local levels
    - Update and standardize health education materials across all levels
    - Provide adequate resources for training and education
    - Improve supervision of health worker training and continued education

- Develop the Cognitive Neurosciences field within Uganda by creating programs to address neurological impairments and disability
- Focus more efforts on improving early-childhood education in rural communities

District Health Office

- Monitor rates of acute and chronic malnutrition within district
- Monitor Vitamin A supplementation, deworming and immunizations in children
- Equip health workers to monitor and identify at-risk children
    - Provide proper growth measurement equipment
        - Find appropriate equipment that can be mobile (ie. VHTs)
    - Ensure health workers are updated on training and are evaluated regularly
    - Regularly assess each health center's protocols and capacity building
    - Reduce need for transport by equipping all health facilities (HC 1- National Referral) to address growth monitoring and nutrition promotion
- Require health facilities to follow holistic approach for children
    - Growth monitoring and promotion every time a child visits a health facility
    - Provide nutrition education for parents
    - Keep a growth chart for children during first five years
- Bridge the knowledge gap between community members and health workers
- Fund programs to build food security and safe water infrastructure in most needed communities

Community and Local Level

- Frequent screening of child growth during first five years
- Properly train and mobilize VHTs in addressing all forms of malnutrition and assisting with community education
- Educate communities on age-appropriate nutrition using local and available foods
- Educate communities on the effects of malnutrition
    - Help families to understand why good nutrition is so important for young children
- Provide incentives for attendance of community health education meetings
- Find ways to counteract burden of transport for families
- Help address food insecurity with community crop storage containers
- Ensure families are drinking safe water, build infrastructure to access clean water

Parents

- Prioritize children's health in the family
- Seek out help and advice on proper child nutrition
- Maintain a diverse diet for children, with age-appropriate food preparation
- For mothers: exclusively breastfeed for the first 6 months and practice complimentary breastfeeding for up to two years
- Interact with child during infancy to ensure adequate stimulation and development
    - Play games with child, asking questions and practicing memory
    - Talk to the child and teach simple things such as counting and songs
    - Tell stories or read to children (ie. Bible stories, folk tales)

Future Studies

Future studies should look at malnourished children and factors such as deworming, vitamin A supplementation, malaria prevalence, early childhood infections and mother's breastfeeding habits since many of these issues are being addressed in health campaigns. It would also be beneficial to further analyze a child's diet early in life by collecting data on frequency, amount, thickness, variety, active feeding and hygiene of food practices with relation to malnutrition. Understanding these differences within communities may help to unveil reasons why some children are chronically malnourished whereas others remain normal by WHO standards.

Other studies could look further into the differences in cognitive achievement between rural and urban environments, which are very relevant to Uganda because most of the population lives in a rural setting. Chronically malnourished children in urban and rural settings should also be compared to better understand if the differences observed are due to socioeconomics or environmental setting. A limitation to the present study was the inability to obtain an urban stunted group due to the time constraints.

Additionally, more research needs to be conducted on the cognitive impacts of psychostimulation in young children under five who are stunted. Longitudinal studies within Ugandan communities would also be helpful in assessing a child's mental development throughout the first five years of life. Lastly, cognitive assessment tools that are more appropriate for low-income countries and diverse cultural backgrounds need to be developed so that cognitive abilities can be more accurately measured.

6.1 Conclusion

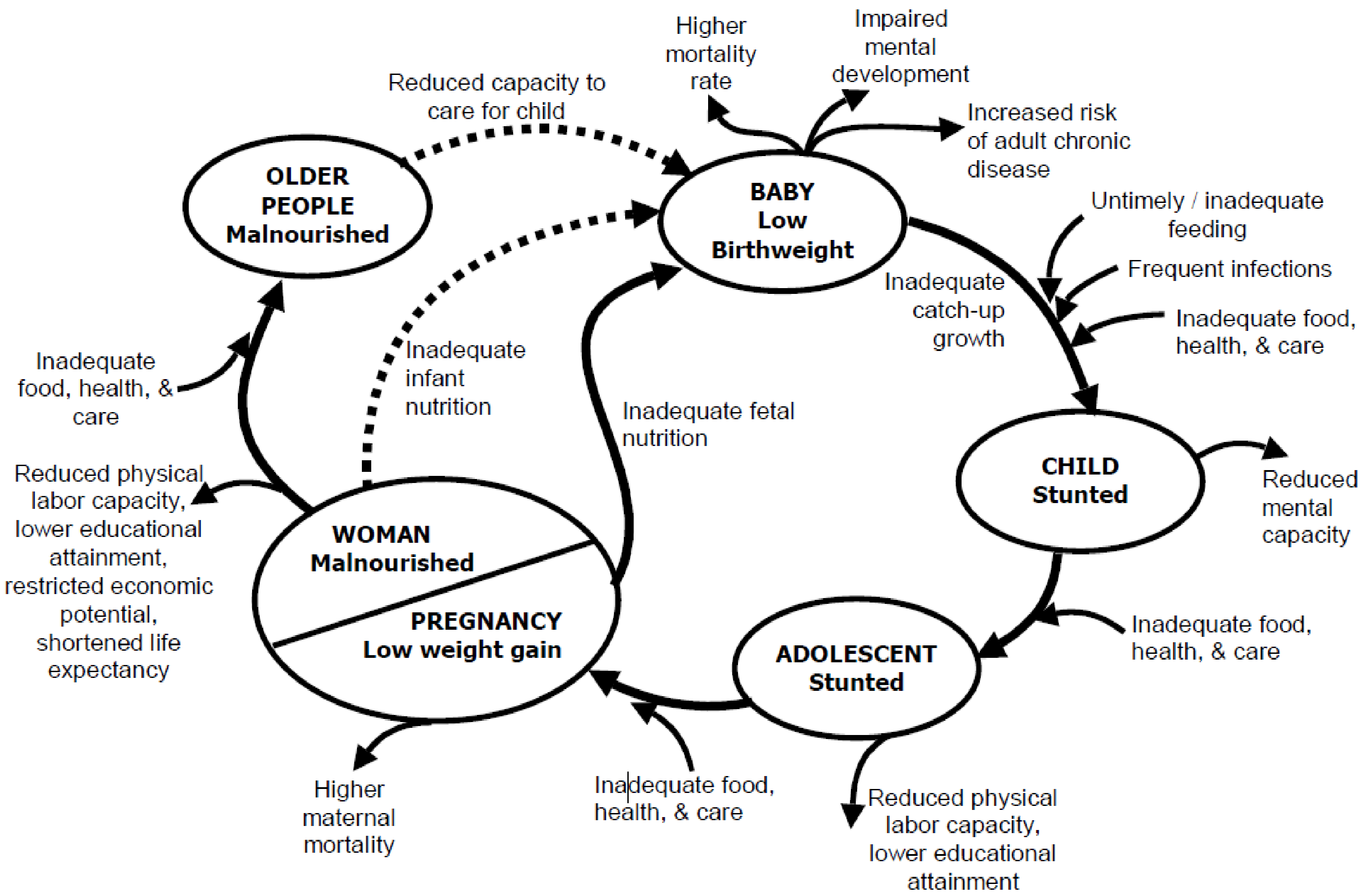
The purpose of this study was to establish a relationship between chronic malnourishment and cognitive impairments which affect the working memory. It additionally sought to compare cognitive performance among rural and urban children and analyze its results within the children's background environment. Chronic malnourishment, indicated by stunting, results in cognitive impairments, specifically to the working memory and executive functions. Stunting correlates with poorer cognitive performance on assessments requiring higher order cognitive processing, which has adverse implications for a child's educational outcomes. The impacts of chronic malnutrition are most severe during early childhood when the majority of brain development occurs, making it imperative to prevent early on in life. Additionally, differences in cognitive performance between rural and urban children suggest that additional factors in early childhood may effect brain development and function. These factors could be attributed to educational backgrounds, home environment, diet or cultural differences. The observed differences indicate that rural children may be at an academic disadvantage to urban children even before they begin primary school.

Delayed cognitive development can place an especially high burden on individuals in a resource-constrained environment such as the Namayumba community, which is likely to be paralleled in other regions of Uganda. The large-scale impact of chronic malnutrition can hinder the development of the nation as a whole, adversely affecting the country's productivity and growth. Without taking actions to reduce the high rates of malnutrition and improve early-childhood education, development as a whole may remain in a "stunted" phase with little growth and further decline in opportunity for the nation.

Appendix

Appendix A

Malnutrition's Impact on Productivity during the Life Cycle and Across Generations [1]



[1] UNAP- 2009-2016

Appendix B

Parent Questionnaire

Participant ID:______________________ Child's Age:________________________

In what setting was your child born?

A. Government Hospital (HC IV, Regional or National)
B. Local Health Center (II or III)
C. Private Hospital
D. Traditional Birth Attendant
E. Other (please specify):______________________

Was antenatal care used during pregnancy?

A. Yes
B. No

How long was the child breast fed for? _____months

During the first three years of life, did the child have any of the following:
(Please indicate yes with a tick)

____ Malaria
____ Typhoid
____ Iron Deficiency Anaemia
____ Chronic disease (HIV, TB etc.)
____ Malnutrition

During the first 3 years of life, How many times was your child fed the following foods in a week?
(Please indicate by circling the appropriate number)

Starch (Matoke, maize, rice, cassava, posho, bread etc.)

None 1-2 per week 3-5 per week 6 or more per week

Meat (chicken, fish, beef, goat, pork etc.)

None 1-2 per week 3-5 per week 6 or more per week

Other Protein (peas, lentils, g-nuts, beans, eggs, cow's milk etc.)

None 1-2 per week 3-5 per week 6 or more per week

Vegetables (greens, carrots, cabbage, avocado, onion, eggplant tomatoes, etc.)

None 1-2 per week 3-5 per week 6 or more per week

Fruits (jackfruit, watermelon, mango, banana, pineapple, orange etc.)

None 1-2 per week 3-5 per week 6 or more per week

Appendix C

Ebibuuzo by'omuzadde

Namba ye: ______________________ Emyaka gy'omwana________________________

Omwana wo yazaalibwa wa?

A. Eddwaliro lya gavumenti (Health centre IV, ey'omukitundu oba eyegwanga)
B. Eddwaliro ly'omukitundu (II or III)
C. Eddwaliro ery'obwananyini
D. Omuzaalisa w'okukyalo
E. ekirala (tulage): ______________________

Wanywa eddagala?

A. Yee
B. Nedda

omwana yayonkera banga ki? _____

Emyaka esatu egyasooka omwana yafunaku kimu ku bino? (Laga yee kozesa tiki)

____ Maleriya, omusujja

____ Tayifoyidi

____ Talina musaayi

____ Endwade ez'olukonvuba (silimu, akafuba endala.)

____ Okulya obubi

Mu myaka esatu egyasooka, emirundi emmeka omwana wo bweyaweebwa emmere eno wansi mu wiiki? (Teeka saako ku namba entuufu)

Eleeta amaanyi (Matooke, kasooli, omuceere, muwogo, akawunga, omugaati etc.)

Tewali 1-2 buli wiiki 3-5 buli wiiki 6 oba okusingawo buli wiiki

Ennyama (enkoko, ebyanyanja, ennyama y'ente,embuzi, embizzietc.)

Tewali 1-2 buli wiiki 3-5 buli wiiki 6 oba okusingawo bui wiiki

Endala ezimba omubiri (kawo, enva endiirwa, ebinyeebwa, ebijanjaalo, amaggi, amata g'ente etc.)

Tewali 1-2 buli wiiki 3-5 buli wiiki 6 oba okusingawo buli wiiki

Enva endiirwa (doodo, kaloti, emboga, ovakedo, obutungulu, birinnganya, ennyannya, etc.)

Tewali 1-2 buli wiiki 3-5 buli wiiki 6 oba okusingawo buli wiiki.

Ebibala (fene, watermeloni, emiyembe, bogoya, ennaanansi, emicungwa etc.)

Tewali 1-2 buli wiiki 3-5 bui wiiki 6 oba okusingawo buli wiiki.

Appendix D

SIT Study Abroad
a program of World Learning

CONSENT FORM

1. **Brief description of the purpose of this study**
   My name is Kristiana Morgan, a study abroad student at the School for International training in Kampala, Uganda. I'm conducting a 6 week research project on the Cognitive Effects of Malnutrition in Children and I am seeking your participation for my study.

   The purpose of this study is to establish a relationship between malnutrition and cognitive development in children by conducting cognitive tests which assess working memory and attention. The study will also compare the cognitive results and health backgrounds of children between rural and urban settings. The finding of the study will help indicate the long term effects of malnutrition, which impact human development in Uganda. Although there is no direct benefit to the participant for partaking in this study, the findings will be made available to participants. Additionally this study will help contribute to the literature representing child malnutrition in Uganda.

2. **Rights Notice**
   In an endeavor to uphold the ethical standards of all SIT ISP proposals, this study has been reviewed and approved by a Local Review Board or SIT Institutional Review Board. If at any time, you feel that you are at risk or exposed to unreasonable harm, you may terminate and stop the assessment. Please take some time to carefully read the statements provided below.

   a. ***Privacy*** - all information you present in this survey may be recorded and safeguarded. Personal health history information will be de-identified to ensure privacy with a participant ID number for the survey. The results of the child's assessment will remain anonymous unless the parent wishes to obtain results.

   b. ***Anonymity*** - all names in this study will be kept anonymous using participant ID numbers.

   c. ***Confidentiality*** - all names and responses will remain completely confidential and fully protected by the researcher. By signing below, you give the researcher full responsibility to uphold this contract and its contents, as well as consent for your child. The researcher will also sign a copy of this contract and give it to the participant.

___________________________	_______________________________
Participant's name printed	Participant's signature and date
___________________________	_______________________________
Researcher's name printed	Researcher's signature and date

Appendix E

Fomu ey'okukkiriza

3. Okunnyonyola okutono ku kigendererwa ky'okusoma kuno.

Erinnya lyange nze Kristiana Morgan, ndi muyizi mu study abroad mu School for International training mu Kampala, Uganda. Nkola okunnyonyereza ku ngeri endya embi bwekosamu okusoma kw'abaana okumala wiiki mukaaga era nkusaba okwenyigira mu kunnoonyereza kuno kinsobozese okukola okusoma kuno.

Ekigendererwa ky'okusoma kuno kwekuzuula okulya obubi bwe kukwataganamu n'okutegeera kw'abaana nga ngezesa okutegeera kw'abaana okugenda okukebera okujjukira n'okussayo omwoyo mu baana. Okusoma era kujja kugerageranya ebivudde mu kutegeera n'ebyafaayo ku by'obulamu bw'abaana abasangibwa mu bibuga ne mu byalo. Ebinaazuulibwa mu kusoma bijja kuyamba okulaga okulya obubi bwe kukosamu abantu ne mu bukulu, ekikosa okukulakulana kw'abantu mu Uganda. Newankubadde nga tewali ky'ojjakufunirawo mu kwennyigira mu kusoma kuno,ebinaazuulibwa bijja kusoboka okulabibwa abakwenyigiddemu. Okwongereza kwekyo okusoma kuno kujja okwongera ku biwandiikiddwa nga biraga okulya obubi mu baana ba Uganda.

4. Eddembe lyo

Mu kugezaako okukuuma omutindo gw'empisa ezifuga ebinnoonyerezebwako mu SIT, okusoma kuno kwekeneenyerezebwa era ne kukakasibwa ab'ekitongole ekyawano ekyetegeereza ebiwandiiko oba ab'ekitongole ekya SIT ekyetegereza ebiwandiiko.

Singa essaawa yonna,owulira nga ali ku bunkenke oba nga anaakosebwa, osobola okkusazaamu era n'oyomiriza okubuuzibwa. Bambi twala akaseera osome n'obwegendereza ebiwandiikiddwa wansi.

d. ***Eby'ekyama*** – obubaka bwonna bwowa mu kunoonyereza kuno buyinza okukwatibwa ku katambi era ne bukuumibwa. Ebyafaayo eb'yobulamu bwo tebijja kulagibwa nga tukozesa namba eyoyo eyenyigidde mu kunoonyereza. Ebinaava mu kunoonyereza ku mwana bijja kusigala nga byakyama okujjako ng'omuzadde ayagala okulaba ebyavamu.

e. ***Okukweka erinnya*** – amannya gonna mu kusoma kuno gajja kukwekebwa nga tukozesa namba eri abo abakwenyigiddemu.

f. ***Eby'ekyama*** – amannya gonna n'ebyebazzemu bijja kusigalira ddala nga byakyama era bijja kukuumibwa butiribiri akola okunoonyereza. Okuteeka omukono wansi,owa okola okunoonyereza obuvunanyizibwa obujjuvu okunweza endagaano eno n'ebigirimu, n'okukkiriza kw'omwana wo. Akola okunoonyereza naye ajja kuteeka omukono ggwe ku ndagaano eno era agiweko eyenyigidde mu kunoonyereza.

________________________ ________________________

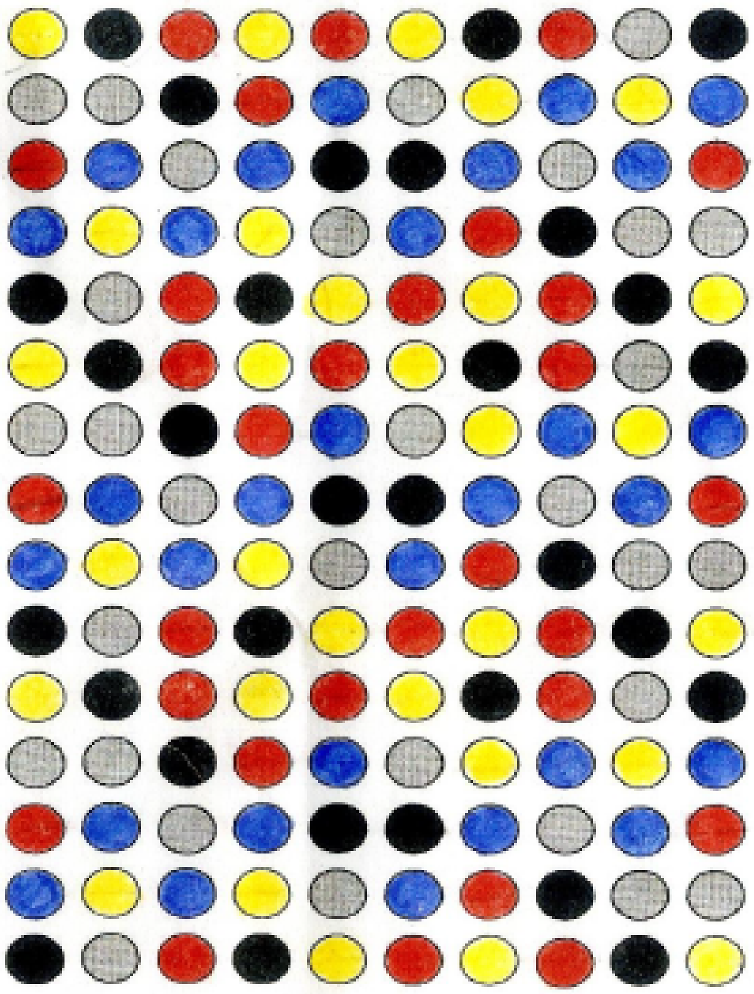
Erinnya ly'eyenyigidde mu kunoonyereza | Ekinkumu n'ennaku z'omwezi.

________________________ ________________________

Erinnya ly'anoonyereza | Ekinkumu n'ennaku z'omwezi

Appendix F

Color Cancellation Test



Appendix G

Digit Span Test

DIGITS FORWARDS

Item	First trial	√ or X	Second trial	√ or X	Total
A	43		16		
B	792		847		
C	5941		7253		
D	93872		75396		
E	152649		216748		
F	3745261		4925316		
G	82973546		69174253		
H	246937185		371625948		
				Forwards score:	

DIGITS BACKWARDS

Item	Trial one	√ or X	Trial two	√ or X	Total
A	83		29		
B	475		615		
C	2619		3852		
D	28736		59413		
E	624719		276391		
F	4183627		1586937		
G	52624197		94617385		
				Backwards score:	

FINAL SCORE:

Total Forwards and Backwards:

Appendix H

FAS Phonemic Fluency Test

F (Ma)

A (Ok)

S (Mu)

Score: Total number of words generated:______________

Glossary

BMI- Body Mass Index: Weight in kilograms divided by the height in meters

Malnutrition- A condition resulting when a person's diet does not provide adequate nutrients for growth and maintenance or when a person is not able to adequately utilize the food consumed due to illness. Malnutrition encompasses both under nutrition (too thin, too short, micronutrient deficiencies) and 'overnutrition' (overweight and obesity), which should actually be considered 'unbalanced nutrition' as it often co-occurs with micronutrient deficiencies.[2]

MUAC- Mid upper arm circumference, used to monitor growth in children

Muzungu- Swahili term used to identify a white person or a foreigner; used frequently throughout Uganda

Stunted – Indication of slowed growth and development due to chronic malnutrition. Gradual and slow process with irreversible consequences. Height-for-age is further than -2 z scores from the median height.

Underweight- Underweight reflects both stunting and wasting. Weight-for-age is further than -2 z scores from the median

VHT- Village Health Team member; a volunteer health worker who oversees general health practices within a small community setting. Responsible for monitoring health of families and mobilization within village zones as a trusted community member.

Wasted- Indication of acute malnutrition. Characterized by sudden, rapid weight-loss and failure to gain weight. Strongly related to mortality and often shows signs with edema (swelling), hair loss and other symptoms. BMI-for-age is further than -2 z scores from the median.

WHO- World Health Organization: Agency of the United Nations, established in 1948 that is concerned with international public health

[2] World Food Programme: Hunger Glossary

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