CHAPTER ONE

1. INTRODUCTION

1.1. Background

Human Immunodeficiency Virus (HIV) is a virus that causes Acquired Immuno Deficiency Syndrome (AIDS), a disease of the immune system (Kaplan & Saddock 2007; Kalings 2008). The infection is less prevalent in developed countries and more prevalent in developing countries like Zambia. In some developing countries like Swaziland, Bostwana, Lesotho, rates of infections are as high as 20 - 30 percent (UNAIDS 2010). Sub-Saharan Africa is a region that is most affected by HIV. According to UNAIDS (2010), sub-Saharan Africa accounts for approximately 70% of people infected with HIV worldwide. The region also accounts for about 72% of the world's HIV death related cases. It is in this vein that governments from various African countries embarked on developing measures to deal with the infection. It is as a result of such measures that Zambia has recorded a decrease in adult HIV prevalence among women and men from 16% to 14 % respectively (Zambia Demographic Health Survey 2007).

HIV affects the lives of all human beings in a number of ways. According to Annuziata (2003), HIV infection results in viral entry into the central nervous system (CNS). As endurance with HIV infection improves, the number of people harbouring the virus in their CNS which is basically impervious to some highly active antiretroviral therapeutic drugs (HAART), increases. Thus the prevalence of HIV associated neurocognitive disorders (HAND) continues to increase (Mattson 2005). Woods (2009) also demonstrates that despite effective general treatment and improved rates of survival, the high prevalence and adverse functional impact of HAND have endured in the era of Antiretroviral Therapy (ART) and continue to present itself as a prominent public health issue. In the past 15 years, considerable progress has been made in revealing the cognitive architecture of HAND which primarily revolved around slowing of psychomotor functions and cognitive control over mental operations, probably reflecting

the influence of disrupted brain circuits on distributed neural networks critical to cognitive functions.

According to a study by Heaton et al. (1995), there are increased rates of neurcognitive impairment at each clinical stage of infection. Heaton et al. (1995) also established that a number of cognitive domains are affected by the virus and these are executive functions, memory, language, attention, learning and speed of information processing (SIP).

Neuropsychological studies of HIV-positive groups in sub- Saharan Africa have found that HIV affects cognitive functioning bringing about impairment in daily functioning. Robertson et al. (2007) assessed 110 HIV-positive and 100 HIV-negative adults in Uganda. Of the participants who were infected with the virus about 40 had been on ART. Robertson et al. (2007) also showed that HIV positive adults performed worse on the neurobehavioural test battery as compared to HIV negative adults (the control group). Singh et al. (2010) also established that HIV affects cognitive functioning and that there is need to develop norms for brief neuropsychological test batteries that will help in quick assessment of cognitive impairment in adults infected with HIV. In Zambia, Hestad et al. (2012) have observed that there is a clear effect of HIV on neuropsychological functioning and that gender may have an effect on neuropsychological test performance in HIV positive adults. These and many more studies have proved that HIV brings about a number of complications in the brain therefore affecting the quality of life for most individuals infected with the virus (Heaton et al., 1995; Cysique et al., 2009; Nyamnshi et al., 2008).

HIV not only affects neurcognitive functioning but it also affects nutritional status of people infected with it. Consequences of chronic viral infection may have organ-specific effects as well as general effects on health. HIV infection is a nutritionally progressive disorder with major metabolic changes in nutrient utilization as the balance of viral replication, immune response and inflammation changes occur over a period of time. HIV treatment has its own specific metabolic effects (Sztam, 2010).

Nutrition worldwide is an important determinant of survival in HIV positive adults and children. States of normal and abnormal nutrition may affect the progression of HIV and response to ART treatment in different ways (Sztam, 2010; Zambia food and composition tables 2009).

According to Nerad et al. (2003) nutritional management is integral to the care of persons infected with the virus. HIV usually results in complicated nutritional issues for infected persons. Severe malnutrition and weight loss can affect morbidity and mortality.

Kalanda et al. (2010) reports that nutrition is one of the major challenges that HIV infected individuals face. Poor nutrition usually results in death whereas good nutrition results in survival of the individual (Kalanda et al. 2010).

Asenso - Okyere et al. (2010) reported that good nutrition is recommended for delaying opportunistic infections and prolonging the lives of individuals infected with HIV. In most cases households that have patients in their final stage of the infection and are burdened with high costs of managing the condition, adopt reduction of consumption of basic needs, including food as a way of coping. This eventually leads to worsening of nutritional status of adults that in turn affect the duration of labour force participation and consequently the welfare of the household including the development of children. Nutrition plays an important role in the fight against HIV. Lack of sufficient food and nutrients usually leads to poor health and eventually death.

Apart from playing an important role in survival, nutrition also plays an important role in cognitive functioning. Good nutrition can bring about improvement in cognitive functioning. Malnutrition that is the lack of nutrients to sustain functioning of the brain may lead to cognitive impairment in individuals of various ages (Williams, 1997). In support of this notion White and Wolraich (1995) showed that glucose plays an important role in potentiating memory processes, this distinction has been observed in both rats and in human beings. Liewellyn et al. (2010) also demonstrated the importance of adequate levels of nutrients on cognitive functioning. The researchers observed that serum albumin plays a vital role in the binding of drugs, hormones, iron and free fatty

acids, and reduced levels of serum albumin may contribute to cognitive impairment. Low levels of albumin in the brain and cerebrospinal fluid may lead to increased Alzheimer's type pathology. While serum albumin levels may lead to cognitive impairment, the reverse is also possible. The statement simply means that cognitive impairment may result in lowered serum albumin. For example, cognitively impaired individuals who are unable to feed themselves effectively may become malnourished, and malnutrition in these individuals may result in low levels of serum albumin. Ng et al. (2008) also found that low levels of albumin are associated with low cognitive performance. Ng et al. (2008) also considered the effects of low haemoglobin and Body Mass Index (BMI) in relation to cognitive performance. The results of the study showed that low levels of haemoglobin and low BMI are associated with poor cognitive performance in the elderly.

The authors suggest that HIV, nutrition (either normal or abnormal) affect cognitive functioning separately. However there is little knowledge in literature on the effects of malnutrition as a co- morbid factor on cognitive functioning in HIV infected adults especially in Zambia. It is on these grounds that malnutrition as a co-morbid factor in HIV positive was the main focus of the study.

1.2. Statement of the Problem

Nutrition is one of the most important components of survival among HIV positive individuals. Malnutrition in human beings especially in individuals who are HIV positive can cause death. It is unfortunate that some HIV positive individuals do not have access to nutrition and nutritional counselling especially in resource limited countries therefore bringing about a number of complications such as malnutrition which in turn might affect activities of daily living. Poor nutrition might also lead to high susceptibility to diseases. A number of studies have shown that nutrition and HIV are inseparable (Obi, Ifebunandu & Onyebuchi, 2010) and that they individually affect cognitive processes which in turn might affect the quality of life of people infected with the virus. The relationship between nutrition and HIV has not yet been completely

understood. From the literature, the effect of malnutrition as a co-morbid factor on neuropsychological performance in HIV positive individuals is not a well established fact. Therefore the study determined the effects of malnutrition as a co-morbid factor on neurocognitive functioning in HIV positive individuals in Lusaka.

1.3. Study justification

The study investigated the effects of malnutrition as a co- morbid factor on neurocognitive functioning in HIV positive adults. The study was aimed at helping HIV positive patients, medical practitioners and other stakeholders understand the importance of nutrition on neurocognitive functioning in HIV positive adults. The study also addressed the implications of malnutrition as a co-morbid factor on cognition in adults and it also identified which neurocognitive domains are more affected by malnutrition as a co-morbid factor in HIV positive adults. It has been identified from literature that there are very few studies on this particular topic. Most studies involving nutrition and cognitive performance are centered on children and adults above the age of forty. Therefore the study addressed these existing gaps in literature. It is expected that knowledge from the study will help in clinical management of HIV positive individuals by providing ample information on the importance of nutrition on cognitive functioning and quality of life in adults below the age of 65.

1.4. Research questions.

1.4.1. What are the effects of malnutrition as a co-morbid factor on neurocognitive functioning in HIV positive individuals?

1.4.2. Which neurocognitive domains are more affected by malnutrition as a co-morbid factor in HIV infected adults?

1.4.3. Do both variables of gender and nutritional status have an effect on neurocognitive test performance in HIV positive adults?

1.5. Objectives

1.5.1. General objective

To investigate the effects of malnutrition as a co – morbid factor in HIV positive adults on neurocognitive functioning.

1.5.2. Specific objectives

1.5.2.1. To find out the effects of malnutrition as co-morbid factor in HIV positive adults on neurocognitive functioning.

1.5.2.2. To identify which neurocognitive domains are more affected by malnutrition as a co-morbid factor in HIV positive adults.

1.5.2.3. To determine whether both gender and nutritional status have an effect on neurocognitive test performance in HIV positive adults.

1.6. Hypotheses

1.6.1. Malnutrition as a co – morbid factor will reduce neurocognitive test performance in HIV positive adults.

1.6.2. Malnutrition as a co- morbid factor will impair the following cognitive domains: learning, recall, speed of information processing, verbal fluency and executive functioning.

1.6.3. Both gender and nutritional status will improve neurocogntive test performance.

1.7. Identification of Variables

Variables	Operational definition	How it was measured in this study.
Independent variables Nutrition (normal and abnormal)	a measurement of the extent to which an individual`s physiological need for nutrients is being met.	Body Mass Index (BMI), total protein, glucose, Hemoglobin levels and demographic questionnaire.
Gender	Is defined as a binary feature on the basis of self report.	Social-demographic questionnaire.
Dependent variable Neurocognitive test performance.	Performance on various tests that assesses an individual`s cognitive functioning.	International Neurobehavioural Test battery.

CHAPTER TWO

2. LITERATURE REVIEW

This section of the thesis contains a review of literature on how nutritional status and malnutrition as a co – morbid factor affects performance on neuropsychological tests. It will first and foremost look at studies that give ample evidence that HIV affects neurocognitive functioning. It will afterwards look at the relationship between HIV and nutrition (normal or abnormal). It will further outline some studies on the effects of nutrition, malnutrition, gender on neurocognitive functioning. The information was obtained from the following sources: internet (Pubmed, Google Scholar, Hinari and Directory of Open Access Journal); library (books, journals) and organisations like Central Statistical Office (CSO), National AIDS Commission and National Nutrition Commission. The key words used in searching for the information are as follows: HIV globally, AIDS Globally, nutritional status, malnutrition, cognitive processes, adults, gender, Zambia, Africa, BMI, total protein, glucose, haemoglobin and neurocogntive effects.

2.1. Neuropsychological measures

Neuropsychological measures consist of broad based neuropsychological test batteries and they have been used to assess the presence, location and extent of cerebral damage (Strauss, Sherman & Spreen, 2006). A test battery is a collection of tests that assess more than one brain function. Some of the batteries that are developed for neuropsychological assessment are as follows: Halstead – Reitan battery, Repeatable Cognitive – Perceptual – Motor Battery, Halstead Russell Neuropsychological Evaluation, Kaplan – Baycrest Neurocognitive Assessment, Luria `s Neuropsychological investigation, Luria – Nebraska Neuropsychological battery and the Neuropsychological Assessment Battery. All the batteries consist of a series of tests that are sensitive to brain damage (Lezak, 2004).

Faced with the problem of identifying early evidence of cognitive deterioration in HIV positive adults, a number of researchers have developed a set of standardized tests that

are useful in clinical practice as well as research. According to Butters and Grant (as cited in Lezak, 2004) a test battery should include tests of relatively sturdy functions such as vocabulary, that tend to withstand the virus and tests of vulnerable functions such as tests involving response speed, attention capacity, memory, language, visualspatial, construction abilities and motor abilities.

Most batteries used in resource limited settings consist of Western Neuropsychological measures that are chosen for their cultural neutrality and sensitivity to the effects of HIV. In the batteries, the ability domains that are represented include executive functions, attention/working memory, learning, memory (delayed recall), speed of information processing, language fluency, and motor speed/dexterity (Gupta, 2011). The International Neurobehavioural Test battery has been used not only in developed countries but also in developing countries like China (Gupta, 2011), Uganda (Robertson, 2006) and Cameroon (Nyamnshi, 2008). The battery has also been used before in Zambia but this was before the establishment of norms (Holguin, 2011).

2.2. HIV and Cognitive functioning

Adults infected with HIV are at high risk of developing neurocognitive impairment as compared to adults who are HIV negative. There has been overwhelming research in support of the notion that HIV is often associated with potentially devastating forms of neurocognitive disorders.

According to a study by Cysique et al. (2009) which was undertaken in China among HIV infected former plasma donors who were on ART, cognitive decline was still prominent in persons infected with HIV despite being on ART. For this study, the researchers recruited 192 HIV positive adults and 101 HIV negative adults. All participants were former plasma donors and they all lived in rural China. All participants were examined for any medical or neuropsychological pathology. Of the total number of HIV positive individuals 56% were on a combination of ART at study entry and 60.9% were on ART at follow-up. Follow up was after a period of one year.

The results of the study indicated that there was a significant decline in cognitive performance in 53 HIV-positive individuals as compared to 5 individuals who were HIV

negative. Decline in cognitive functioning was predicted at baseline by HIV status, lower CD4, and worse processing speed. And at follow-up, it was connected to lower current CD4 cell count and failure of viral suppression by ART. Decline in neurocognitive performance was also linked to decrease in activities of daily living.

The research is important because it highlighted the fact that despite the introduction of ART, HIV continues to affect the functioning of the brain bringing about decline in cognitive functioning as well as activities of daily living. Therefore it is cardinal for researchers as well as clinical practitioners to know when to initiate ART. However the weakness of this study was that it did not consider other factors such as obtaining of information about the duration of the infection from self report; this form of information cannot be relied upon because of its subjective nature. It should be emphasized that some participants tend to distort information about their medical conditions. Thus it is important for self reported information to be accompanied by medical records and examination.

The other aspect is that, in the study there was no information on gender. This information is important in determining the effect of gender in the decliners and non-decliners` groups.

Another study conducted in Zambia showed results that were similar to those found in the Chinese study. Holguin et al. (2011) concluded that HAND is present in HIV positive individuals in Zambia where subtype C infection is common. The study consisted of a total number 141 adults who were both HIV positive and HIV negative. These participants were recruited by referral through the collaborating medical staff at University Teaching Hospital. Neuropsychological assessment tools and the International HIV Dementia scale were used to assess cognitive impairment. The study included 57 HIV negative adults (control group), 54 HIV positive adults who were not on ART (HIV+ group), and 29 HIV infected adults who were on ART treatment (ARV group). The results of the study showed that 22% of HIV positive individuals who were not on ART met the criteria for International HIV Dementia Scale-defined Neuropsychological impairment. In the study gender significantly influenced the performance on neuropsychological tests with males performing better than the females.

This study is relevant to the current study for the following reasons firstly the socio demographic features of the study are similar to those in the current study. Secondly it highlighted the fact that HAND is common in Zambia and that there are gender differences in performance among adults in Zambia. Therefore, there is need for more researchers to focus on this particular aspect and try to identify reasons for this difference in cognitive performance.

Robertson et al. (2007) evaluated the pattern of neuropsychological performance of HIV positive individuals in comparison to HIV negative controls in Uganda. The neuropsychological test scores of 110 HIV positive adults on various World Health Organisation (WHO) stages of the infection (WHO Stage 2, n = 21; WHO Stage 3, n = 69; WHO Stage 4, n= 20) were compared to the control group (the group consisted of HIV negative adults with the same mean age and level of education as the treatment group) on measures of attention/concentration, mental flexibility, learning/memory, and motor functioning. There were more females in the treatment group as compared to the control group. The results showed that there were significant group differences in performance on tests of learning, memory, speed of information processing, attention and executive functioning between the two groups. The conclusion of the study was that individuals infected with HIV in Uganda demonstrated deficits on tests of verbal learning and memory, speed of processing, attention and executive functioning compared to HIV negative individuals. The results are consistent with results from previous studies in developed countries where clade B is mostly dominated.

The researchers highlighted the fact that HIV affects most of the neurocognitive domains bringing about a decline in neurocognitive functioning. The study is relevant because it allows one to have a clear picture of what to expect during data analysis. Even though in most resource limited countries where there is the prevalence of other HIV clades the pattern of performance is consistent with pattern of cognitive performance from developed countries. This simply means that similar results can be obtained from a similar study that is conducted in Zambia. Further, the researchers supposed that speaking Luganda is a substitute marker for a number of factors, such as lower socioeconomic status, decreased access to health care and decreased nutritional status.

Therefore it is also for this reason that the aspect of nutritional status was put into consideration. It is a vital component of cognitive functioning in adults.

Nyamnshi et al. (2008) in their study found that there is a higher prevalence of possible HIV associated dementia (HAD) /HIV- associated cognitive impairment (HACI) in Cameroon than was previously reported and demonstrated that International HIV Dementia scale (IHDS) should be used as a screening tool. HIV positive adults were matched to HIV negative subjects for sex and age (age ranging from 18 – 60) and the participants in both groups were screened using IHDS. The findings were that a total of 408 HIV positive and negative adults were screened using the scale mentioned above. And the results showed that the treatment group (HIV positive adults) had significantly lower scores on the IHDS compared to the control group (HIV negative adults). In both groups abnormal scores were found on IHDS. More abnormal scores were found in the treatment group.

The study at hand is very important because it stressed the importance of screening the patients before the administration of any neuropsychological test. The researchers had also pinpointed the importance of using screening tools that are short, less time consuming but effective. The study is relevant because it had provided information on the use of tools that are highly sensitive in assessment of neuropsychological disorders in HIV positive adults. In light of this it can be stated that the neuropsychological test battery that was used for the current study contains tests that are sensitive and specific to changes in neuropsychological functioning.

2.3. Relationship between nutrition and HIV

Nutrition plays an important role throughout the infection in two ways. First it is a vital component of care for the involuntary weight loss and body tissue wasting caused by the effects of the virus on metabolism. Second, nutrition is an intimate and integral component of care through the specific roles of key nutrients in maintaining the body`s immune competence (Williams, 1997). Nutrition plays an important role in the lives of

people who are infected with HIV. The following are some of the studies that illustrate the importance of nutrition and nutritional assessment in HIV positive men, women and children.

Obi, Ifebunandu and Onyebuchi (2010) in looking at the effects of nutritional status on free Highly Active Antiretroviral Therapy (HAART) treatment in Nigeria indicated that, malnutrition is common among HIV-infected patients in Nigeria. According to literature nutritional status has been used as a predictor of survival in HIV infected adults after adjusting for CD4 count and other secondary procedures. The study was a cross-sectional survey and it was conducted in the southern parts of Nigeria. The study consisted of two groups of participants (study groups and control groups). The study group included 120 men and women who were infected with HIV and the control group consisted of 120 individuals who were without chronic medical problems. Subjective global assessment (SGA) technique was used to survey nutritional status of the study group as well as the control group. The results of the study showed that all participants in the study were physically active with a number of them belonging to lower socioeconomic status. The results of the study also indicated that there were significantly more malnourished individuals in the study group than in the control group ($P < 0.05$). As already alluded to, the researcher concluded that malnutrition is common among individuals infected with HIV and it is a prominent feature in the early stages of HIV infection because of the poor nutritional status.

The study is relevant because the researcher outlined the importance of nutrition in HIV positive individuals. The researchers demonstrated that HIV positive individuals are at a higher risk of developing malnutrition as compared to HIV negative individuals. It can be concluded from the study that there is a relationship between HIV and nutrition.

Severe malnutrition is the most common clinical presentation of HIV in children. To illustrate the significance of nutrition in children, Ndekha, Manary, Ashorn and Briend (2005) undertook a study that looked at whether home-based therapy with Ready-to-Use Therapeutic Food (RUTF) is of any benefit to malnourished HIV-infected Malawian children. The sample consisted of 93 HIV-positive children who were severely malnourished aged between 1 and 5 and were discharged from the Hospital in Blantyre,

Malawi. In order to access the benefits of home based therapy, the children were allocated to one of three dietary regimens: RUTF (which is energy-dense lipid paste made from peanut butter, milk powder, oil, sugar, vitamins, and minerals; RUTF supplement (provided 2090 KJ of energy) and blended maize/soy flour. The children were taken back to the clinic fortnightly for anthropometric measurements and health assessment. The results of the study showed that 56% of all children reached 100% weight-for-height. Regression modeling found that children on the RUTF regimen gained weight significantly as compared to their counterparts. The children`s weight gain was more rapid and they were more likely to reach 100% weight-for-height than their counterparts in the RUTF and maize / soy flour regimen. The researchers` conclusion was that most malnourished HIV infected children benefited from home-based nutritional rehabilitation. And that home-based therapy RUTF is connected to rapid weight gain and a higher likelihood of reaching 100% weight-for-height.

The researchers underlined the benefits of food supplement on individuals who are HIV positive. However, the study had a number of weaknesses. The main weakness of the study is failure to include information on gender. This information is important in determining effect of gender on nutritional status in children. The study might have been far more persuasive if the authors had include the children`s CD4 count as well as viral load among many other biomarkers.

Opara, Umoh and John (2007) also illustrated that nutrition is of great importance in the fight against HIV in adults. The study was conducted in Uyo, Nigeria and it lasted for four months. It included 290 randomly selected individuals who were HIV positive and reporting for ART. The study consisted of two groups: a control group and treatment group. The treatment group consisted of 144 (78 females and 66 males) individuals who received nutritional counseling and free daily micronutrient supplements. The control group included 146 (76 females and 60 males) individuals who did not receive any counseling or nutritional supplements. All biomarker parameters were assessed at the beginning and end of the study. The results of the study showed that there was a significant difference in the mean gain in packed cell volume between the treatment

group and the control group. The results also demonstrated that there was no significant difference in mean gain in total protein between the male controls and males in the treatment group. However there was a significant difference in mean gain in serum protein between the female controls and the females in the treatment groups. The results confirmed that there was a significant difference in mean gain of parameters of serum.

The researchers concluded that nutritional counseling and micronutrients supplementation are cardinal in improving nutritional status of people who are infected with HIV and are undergoing treatment. The researchers recommended that all persons with HIV should be given person centred counselling on nutrition and micronutrient supplements.

The study had pinpointed the importance of nutrition in HIV positive individuals in developing countries and that all HIV positive adults should be counselled on the importance of a balanced diet. Despite this accomplishment there are a number of weaknesses to this particular study. It is not clearly stated whether the researchers had obtained ethical clearance from the ethics committee in Nigeria. It is not clearly stated how the researchers had managed to handle the issue of not providing nutritional counselling to the control group since nutrition plays an important role in the lives of people infected with HIV.

Rawat, Kadiyala and McNamara (2010) also highlighted the importance of nutrition in HIV positive individuals when they looked at the impact of food assistance on weight gain and disease progression among HIV infected individuals accessing AIDS care and treatment services in Uganda. The researchers utilized data program from The AIDS Support Organization (TASO) in Uganda to weigh against outcomes among participants on food assistance program to a control group. In this case it consisted of individuals who were not food assistance recipients. Propensity score matching (PSM) methods were used to make comparisons among the 14,481 HIV-infected adults. The variables of interest in the study were as follows: 1) change in weight in kilograms, and 2) advancement in WHO disease staging by one or more stages. The results showed that there was a significant mean weight gain of 0.36 among food assistance receipts over a period of one year. Food assistance resulted in mean weight gain of 0.36 kg among

persons not receiving ART as compared to the controls with the same characteristics. HIV-infected individuals receiving food assistance with baseline disease stage of II and III had a significant weight gain of 0.26 kg and 0.2 kg respectively, compared to controls in this group. Individuals in advanced stage (WHO stage IV) of the disease at baseline had the highest weight gain of 1.9kg. The results also showed that individuals receiving food assistance were less likely to progress by one or more WHO disease stages compared to the controls. The authors concluded that food assistance programs have the potential to improve weight and delay disease progression especially among HIV-infected persons who are not on ART.

The study is very important because it highlighted the importance of food assistance on disease progression and weight in individuals who are infected with HIV. The findings are extremely vital for program developers and implementers especially in resource limited settings like Africa.

Onyango et al. (2011) found that excellent dietary practices are necessary for the maintenance of a healthy lifestyle. And that nutritional compromise in persons infected with HIV has been linked to high levels of mortality and morbidity. The study was a prospective cohort study and it consisted of 497 males and females between the ages of 18 and 60. All participants were assessed using BMI. The study was conducted in Kenya. The participants` CD4 count was also determined. The findings were that majority of the participants had a BMI of 18.5 kg/ meter squared and above. Participants in the moderate and severe categories had a BMI of less than 18.5 and 30 respectively. Even though most of the participants were not severely malnourished, malnutrition was observed in all the three categories. And in terms of CD4 count the findings were that most males in the study had a low CD4 count as compared to the women. This can be attributed to the males seeking medical assistance when the infection has progressed and most men are highly stigmatised. Males feel more stigmatised as compared to females. The conclusions of the study were that nutritional status strongly influences the well being and survival of persons infected with HIV (which compromises nutritional status in a complicated way that may produce malnutrition via multiple mechanisms).

2.4. Nutrition (normal and abnormal), gender and cognition.

The link between nutrition (good or poor) and cognition has been recognised for some time now and nutrition can have an effect on mental achievement that can last a lifetime. At the same time the issue of gender cannot be overlooked. Males and females differ not only in body structure but also on how they process information from the outside world as well as their accessibility to nutritional advice. The following studies show how the three variables have been studied and the trends in performance that have been observed among individuals.

Sabia et al. (2009) looked at the association between BMI over the adult life course and cognition in late midlife. The study was a prospective The target population for the study consisted of London – based office, aged between 25 and 65 years. It consisted of 10,308 participants at baseline (phase 1) of which 67% were men. Due to ethic differences in BMI, the researchers restricted analyses to the white population (n = 9181). Of the 9181 white participants at phase 1, 5645 participated in cognitive assessment at phase 7.The researchers assessed the cumulative effects of obesity and underweight. The researchers examined data that indicated BMI categories at different phases of life and also data on cognition in late midlife by means of the Mini-Mental State Examination (MMSE) and tests of memory and executive function, all of which were standardized. The results were that both underweight and obesity were associated with lower cognition in late midlife. A large increase in BMI from early to late midlife was also associated with lower executive function. The conclusion from the study was that obesity and underweight in adulthood are associated with lower cognitive scores in late midlife.

The study is important because it outlined the association between BMI and cognitive functioning. The use of other tests of cognition is a very important aspect rather than just relying on the MMSE.

Gorospe and Dave (2007) concluded that that increased BMI is independently associated with increased risk of dementia in old age. The researchers retrieved and reviewed

longitudinal population-based studies on increased BMI and dementia using a standard protocol. The results were that eight studies that met selection criteria were identified. And they covered 1,688 cases of dementia from 28,697 participants. The results showed that after adjustment for age, smoking, co- morbidities, and other confounders, four studies presented significantly increased risk of dementia with elevated BMI. In this vein a study by Hassing et al. 2010 also concluded there is a relationship between midlife overweight and lower cognitive performance in old age. The fact that BMI-related effects were noted in mean-level cognitive performance, whereas only one ability showed differences in slopes, suggests that the downbeat effect of overweight has an onset before entry into very old age.

Cournot et al. (2006) in a study that looked at the relation between BMI and cognitive function in healthy middle aged men and women. Their study was a prospective cohort study and it consisted of 2,223 participants, aged between 32 and 62. It was conducted in France. Data was collected in 1996 and 2001. The participants were tested at baseline and at follow-up with a number of cognitive tests. The results obtained were that a higher BMI was associated with lower cognitive scores at baseline. A higher BMI was linked at baseline to a higher cognitive decline at follow-up. The association was significant for learning and delayed recall. The researchers concluded that BMI was linked to both cognitive function and changes in learning.

West and Haan (2009) found that abdominal fat in late life appears to be related to an increased risk of dementia, whereas overall obesity appears to be protective. This may reflect age-related changes in body composition and the association of visceral fat with metabolic dysregulation. The study consisted of 1,351 Latin Americans. The participants` BMI and waist circumference were associated with cognitive functioning. The results of the study were that Dementia was diagnosed in 110 participants. Compared with the lowest BMI category, overweight participants had a 48% decreased rate of dementia and obese participants had a 61% decreased rate of dementia.

Morley and Lucas (1997) in looking at nutrition and cognitive development reviewed a number of animal as well as human studies. A number of animal studies reviewed by the authors indicated that nourished animals (rats) were at an advantage as compared to undernourished rats. The advantage was evident in male animals. Rats with permanent deficits performed less than rats in the control groups in a number of tasks namely the maze learning tasks. In this light animal studies have shown that nutritional deprivation affects performance, but it is difficult to generalize their results from measures in animal cognition to human cognition.

Human studies in the review indicated that there had been considerable research on whether a deficiency of specific nutrients at a critical period for brain development and maturation could result in a long term or permanent cognitive deficits in human beings. This has been proved by looking at the roles of protein, zinc and iron in later cognitive functioning and that children who received nutritional supplements performed better than children in the control groups. It has also been reported that breast fed infants perform better than those who were not breastfed.

Laus et al. (2011) reviewed a number of human and animal studies and concluded that there is evidence to show that malnutrition, especially imposed in early life, has significant and lasting implications for the development of cognition both in humans and animals. The researchers basically reviewed studies published in literature by using a combination of techniques that were aimed at finding relevant studies in the field of nutrition and cognition. The studies mentioned in the review had demonstrated that any change that is able to lead to severe or long-lasting malnutrition, early in life or during prenatal period, promotes changes known primarily as cognitive impairments and growth deficits in both humans and rodents. These consequences are results of the impact of malnutrition on cortical development. For instance the right parietal cortex is responsible for visual spatial functions and poor performance on related tests can be linked to impairment in this part of the brain. Another aspect is that malnutrition tends to affect the hippocampus and studies have shown that this part of the brain is important for learning and memory. So changes in hippocampal functioning may result in deficits in learning and memory.

Peters et al. (2008) investigated the relationship between incidence of cognitive decline or dementia in the elderly and anaemia or haemoglobin level. The researchers conducted a review and Meta – analysis of peer reviewed articles. The articles reviewed were between 1996 and 2006 and most of them were longitudinal studies of participants over the age of 65. The findings were that there was a significantly high risk of cognitive decline with low levels of haemoglobin. The conclusion was that when evaluating risk of cognitive decline it is important to consider anaemia.

Beard et al. (2004) `s study aimed at determining whether iron deficiency anaemia (IDA) in mothers altered their maternal cognitive and behavioural functioning, mother-infant interaction and the infant`s development. The study was conducted in South African among poor African mothers. The study was a prospective, randomized, controlled, intervention trial and it was conducted among 3 groups: nonanaemic controls and anaemic mothers receiving either placebo or daily iron. 81 participants were followed from 10 weeks to 9 months after giving birth. Maternal haematologic and iron status, socioeconomic, cognitive, and emotional status, mother infant interaction, and the development of the infants were assessed at 10 weeks and 9 months postpartum. The findings of the study were that behavioural and cognitive variables at baseline did not differ between iron-deficient anaemic mothers and non-anaemic mothers. However, iron treatment resulted in a 25% improvement in previously depressed and stressed mothers. Anemic mothers who received a placebo did not show any improvement on behavioural measures. The method of multivariate analysis showed a strong relationship between iron status variables (haemoglobin, mean corpuscular volume, and transferring saturation) and cognitive variables (Digit Symbol) as well as behavioural variables (anxiety, stress, depression). The study demonstrated that there is a strong relationship between iron status and depression, stress, and cognitive functioning in poor African mothers during the postpartum period.

The study is relevant because it provided knowledge on the effects of iron on cognition and emotion. And that more studies should focus on the effects of iron deficiency not only in women but also in men and in children. However the study would have been

convincing if the authors had included firstly the methods that were used to assess stress, depression and cognition and secondly used a sample that represented the population of women in South Africa.

Hoorweg and Stanfield (2008) looked at the effects of protein - energy malnutrition in early childhood on intellectual and motor abilities in later childhood and adolescence. The study was conducted on children in Uganda. The children were divided into four groups (three treatment groups and one comparison group). Each group consisted of 20 children. The researchers found that the treatment groups fell significantly below the control in anthropometric measurements and in tests of intellectual and motor abilities. The results showed a general impairment of a number of abilities. Intellectual abilities, reasoning and spatial abilities were most affected, followed by memory and rote learning and lastly language ability.

Ward, Carlsson, Trivedi, Sager and Johnson (2005) investigated the effects of BMI on global brain volume in middle age men and women in America. The study consisted of 114 individuals aged between 40 and 66 years. It consisted of 43 males and 71 females. T1-weighted 3D volumetric magnetic resonance imaging was used to evaluate global brain volume. Results from the study were that age and BMI each correlated with decrease in brain volume. BMI did not predict cognition for this particular sample, however high levels of diastolic blood pressure were linked to poor episodic learning performance. The conclusion of the study was that middle aged obese adults may already be experiencing greater brain atrophy and may be at risk of cognitive decline in the future.

Castel, Shaha and Harman-Boehm (2006) investigated gender differences in factors associated with nutritional status of older medical patients. The study design was cross sectional and it consisted of 204 cognitively intact patients aged over 65 and it was conducted in Israel. The results of study were that 32.5% of the men and 48.1% of the women were at risk of under-nutrition. Undernourished had a higher rate of depression, lower cognitive functioning and physical ability. Nutritional risk for men was associated

with higher levels of depression, long stay in the hospital and lack of appetite. As for women nutritional risk was linked to lower functional status and more diagnosed diseases. The researcher concluded that under-nutrition is common among older in-patient and that it is gender related. Females are more at risk for under-nutrition.

Gur et al. (1999) undertook a study that focused on sex differences in brain gray and white matter in healthy young adults: correlations with cognitive Performance. The study was conducted in America and it consisted of 80 participants, 40 males and 40 females, aged between 18–45years. Magnetic resonance imaging (MRI) was used to scan the brain. The researchers established that females had a higher percentage of gray matter whereas the males had a higher percentage of white matter. Volumes of both gray matter and white matter were moderately associated with global, verbal, and spatial performance across groups. However, the slope of cognitive performance and white matter volume was significantly steeper in females. The researcher concluded that sex differences in white and gray matter volume can be associated with differences in cognitive performance.

Hamid, Mitra'z, Hasmiza , Pim, Ng and Manan (2011) investigated the effects of gender and nutritional status on academic achievement and cognitive function among Primary School pupils in one of the rural districts of Malaysia. The study consisted of 249 children between the ages of seven and nine. The study was inclusive of both boys and girls. The instrument used to assess children`s cognitive function was Raven Coloured Progressive Matrices (R- CPM). Results from four subjects were used to access the children`s academic performance. Subjects included Malay language, English, Mathematics and Science. In addition to this information birth weight, height and weight for all the children were recorded. The results indicated that girls performed better in academic tests but got a lower score on the R-CPM when compared to the boys. It was also found that nutritional status was highly correlated with academic performance. At the same time it was found that academic and cognitive scores were also related to birth weight, education of the parent and family income. Results from MANOVA indicated that gender remained a constant predictor of academic

performance. Iron status and haemoglobin were statistically significant predictors of cognitive function. The conclusion of the study was that girls performed better in terms of academics than boys in this population. Nutritional status, education of the parent and family income would be factors that would improve academic performance.

Widenhorn-Müller, Hille, Klenk and Weiland (2008), in Germany, investigated the influence of having breakfast on cognitive performance and mood in 13 to 20 year-old high school students. The study consisted of both males and females aged between 13 and 20. The sample consisted of 104 students. Consent was obtained from the parents as well as the students. The participants were divided into two groups. One group received breakfast and other one did not receive any treatment. After seven days treatment was reversed. Cognitive function was measured using a number of tests. These are tests of attention and concentration, verbal and spatial memory. In addition mood was assessed by means of a self – administered questionnaire. The results of the study indicated that the effects of breakfast were not observed on sustained attention among high school students in Germany. The results also showed that males performed better on tests of visuospatial and memory than the females. It was also reported that levels of alertness increased significantly. Males unlike females reported that they felt more positive after having breakfast. The researcher concluded that breakfast affects cognition and self reported alertness in high school students in Germany.

Kaplan, Greenwood, Winocur, and Wolever (2001) investigated the influence of isoenergetic protein, carbohydrate and fat- containing drinks on cognitive performance. They also inspected whether the time period after ingestion affects cognition. The study consisted of 22 participants, 11 males and 11 females aged between 61 – 79 years. Level of education ranged from 7 to 12 years. After fasting overnight the participants consumed either drinks containing pure protein, carbohydrate (glucose) or fat or non energy placebo on four separate mornings. Cognitive functioning was assessed using MMSE and it was administered 15 and 60 minutes after the participants took the drink. They concluded that consumption of pure protein, carbohydrate and fat all improved performance on memory 15 minutes after ingestion. The researcher found that ingestion

of energy in the absence of elevated blood glucose actually improve memory contrary to common belief that blood glucose concentration must be high for memory to improve.

2.5. Summary on literature review

From the findings of the various studies it can be proposed that nutrition is an important component in the fight against HIV. Proper nutrition increases chances of survival in HIV positive men and women in resource limited – setting countries. It can also be suggested from the various research studies that nutrition either good or bad seems to have an effect on cognitive functioning. Good nutrition results in improvement cognitive functioning whilst malnutrition results in decline in cognitive functioning in HIV negative adults and children. The findings above also indicate that nutrition whether good or bad affect a number of cognitive domains.

CHAPTER THREE
3. METHODOLOGY

This part of the thesis will outline the methods that were used to collect data as well as methods that were used for data analysis.

3.1. Study type

The study was a cross- sectional quantitative study. Participants were required to take neuropsychological tests that assess the functions of the brain and these functions mainly are learning, memory, problem solving, attention, language, motor skills and others. The participants were required to answer questions from the social - demographic questionnaire. Participants were screened for any condition that might have an effect on neurocognitive test performance using the following tests: Substance use questionnaire, Chinese substance abuse history questionnaire and Neurobehavioural medical screen (NBMS)

3.2. Study sample

The sample consisted of 263 participants. The participants were recruited from a number of health centres in Lusaka after consent was obtained from the Ministry of Health and the Biomedical Research Ethics Committee. The sample consisted of 107 (40.7%) men and 156 (59.3%) women from the ages of 20 to 65 with a mean age of 40.78 and a standard deviation of 8.91. Their level of education was from 5 to 20 years of education, with mean of 10.02 and a standard deviation of 2.23.

3.3. Inclusion - exclusion criteria

Inclusion criteria

1. HIV positive adults - HIV positive status confirmed by medical records.
2. Ability read to English –assessed by means of the Zambia Achievement Test (ZAT).

3. Ages between 20 to 65 years old – was determined by means of a demographic questionnaire.

4. Educational level of 5 and above years was obtained from the socio-demographic questionnaire.

5. Ability to give consent – was determined by means of a medical screen and demographic questionnaire. Individuals who were cognitively able to make informed decisions were included in the study.

Exclusion criteria

1. History of any neurological conditions (CNS opportunistic infection, neurosyphilis, history of severe head injury etc) unrelated to HIV positive status - the information was obtained from NBMS and other clinic records.

2. Any serious psychiatric disorders involving psychosis (schizophrenia) that may affect cognitive performance – was obtained from the medical records.

3. Physically unwell – was obtained from the medical records.

4. Significant ongoing substance use, including greater than three drinks per day over the last months or recreational drug use greater than one time per week during the last month – was assessed by means of the substance use and Chinese substance use history questionnaires.

3.4. Sampling Procedure

Participants were recruited from adults who reported to various anti- retroviral clinics/ health centres for care and support after being diagnosed at a Voluntary Counseling and Testing centre (VCT). In the recruitment of participants for the study a number of steps were undertaken and these are:

Step1.

Recruitment of the participants for the study was done at a number of health centres namely Kabwata clinic, Kalingalinga clinic, Chipata clinic, Chilenje clinic, Matero

Reference clinic and Matero Main clinic. The medical personnel recruited the participants at the various study sites on behalf of the researchers. Recruitment of the participants was based on the inclusion and exclusion criteria and all medical personnel at the clinics were informed of the procedure. The criteria were helpful in identifying eligible participants for the study from among those who visit the health centres for care, support and treatment. Participants were provided with information on the study by the medical personnel as well as the researcher. Consent was also obtained from the participants by the student researcher. Only participants who agreed to take part in the study were included in the sample.

Step 2.

The medical practitioners were responsible for all forms of medical evaluations. All medical assessments were conducted by well trained and qualified medical practitioners. The practitioners collected blood from the participants, measures of height and weight (which were used to calculate BMI). All the test results were communicated back to the researcher as well as the medical practitioner at the various study sites. The results were used in determining the participants` nutritional status and level of malnutrition.

Step 3.

The neuropsychological test battery was administered to all participants at the beginning of the session. It was administered after they were screened for any conditions that might affect neurocognitive test performance. Other questionnaires were administered after neuropsychological assessment.

3.5. Instruments for the study.

Several instruments were used in the process of data collection. These instruments included neuropsychological test battery which assesses different domains, questionnaire that provided demographic information, ZAT, psychiatric and drug abuse history. In the assessment of nutritional status/malnutrition the following indicators were considered: BMI, serum total protein, random glucose level and haemoglobin level (The medical

practitioners collected blood for these forms of analysis). A short explanation of these instruments is outlined below:

3.5.1. Neuropsychological Measurements

The International Neurobehavioral Test battery was used in this study. The test battery has been widely used in a number of neurobehavioural studies of HIV and AIDS. It has also been used in Zambia and the norms have already been established. Therefore the results from the tests in the battery can be relied upon. It is a test battery that assesses seven cognitive domains. These domains as well the test used to assess them are as follows:

Executive functioning – consists of the Wisconsin Card Sorting Test **–** 64 cards. The test was originally meant as a test of "abstract behaviour and shift of set". It originally consisted of 60 cards with one to four symbols which are a triangle, a star, cross or circle in the following colours: red, green, yellow and blue. There are no similar cards in this test. In the test, the test taker is supposed to match one of the cards at the bottom of the screen to those that are shown among the four (Lezak, 2004). There are three principles in the way the cards are matched and these may be colour, shape or number of items on the card e.g. three (regardless of the colour or the shape of the items). The feedback given for each response is either "right" or "wrong".

The Halstead Category test (Standard Category Test) was developed by Halsted (1947) to assess the ability to conceptualise qualities such as size, shape, number, position and colour. In its original form it had 336 items with 9 subtests. Reitan in 1948 reduced the subtests to 7 with 208 items. Each subtest has a different principle which may be odd stimulus, number of objects, spatial position, a combination of different principles etc. To complete the test, the participant must rely on feedback based on correct or incorrect guesses to know what the principle in that subtest is.

The Stroop Word- Colour task consists of names of colours printed in a contrasting ink colour. The client is given 45 seconds to name the colours of the ink while suppressing the automatic response to read the word.

Verbal Fluency – was assessed using Controlled Oral Word Association Test - (FAS) and its purpose is to evaluate the unprompted production of words within a limited amount of time (Straus, Sherman & Spreen, 2006). The participant is asked orally to produce as many words as possible, beginning with a given letter in a Trail of three. Test takers are allowed 60 seconds for each trial and are not allowed to produce nouns such as names of a person "Moses" or a place "Kabwe". In the Category Fluency Test (Animals and Actions) the examinee is asked to mention as many names of animals as they can think of in 60 seconds and the same time is allocated for the actions test, where a person is asked to itemise as many things as possible that people do.

Motor Dexterity– "Grooved Pegboard (Dominant and Non- Dominant Hand trials) assesses eye-hand coordination and motor speed" (Strauss et al., 2006). This procedure measures performance speed in a fine motor task. The Grooved Pegboard consists of a metal board with 25 randomly positioned holes. Pegs have a groove that is a round side and a square side. The participants' task is to insert the pegs in the holes as fast as possible in sequence without skipping any hole.

Speed of information processing (SIP) – this includes Digit Symbol & Symbol Search. The two tests make up the processing speed index of the WAIS-III. In the Digit symbol, the participant is asked to match a symbol with a specific digit. In the symbol search, the test taker is asked to look at two shapes on the left and state whether any of the shapes are on the group of shapes on the right side by answering "YES" or "NO" on the spaces provided. In the Stroop Task, the colour card (C) in particular measures speed of information processing. The colour card consists of a series of 'X's printed in green, red and blue. The participant is asked to name the colours as quickly as possible while maintaining precision. Trail making test Part A consists of numbers that are encircled. The numbers range from 1 to 25 and the main objective of the test is for the participant to connect the numbers in order in a short period of time. The Trail Making Test (TMT) is a brief, easily administered tool that is widely used to measure motor speed, visual attention, and cognitive flexibility. The Colour trails test Part 1 is designed to minimize the influence of

language so that it can be used in cross-cultural settings. The test has all odd-numbers circled pink and all even-numbers circled yellow; it shows all numbers ranging from 1 to 25, alternating between pink and yellow circles (Strauss, Sherman & Spreen, 2006).

Learning and delayed recall – Hopkins Verbal Learning Test – Revised (HVLT-R) is a test of learning ability and delayed recall on verbal information across three trials. It also measures an individual's capacity to retain, reproduce and recognize information after delay (Strauss, Sherman & Spreen 2006). The Hopkins Verbal Learning Test-Revised is comprised of 12 nouns with four words drawn from three semantic categories i.e. four words each from four legged animals, precious stones and human shelter. Brief Visuospatial Memory Test – Revised (BVMT-R) measures visual learning and memory using a multiple-trial list learning model. It measures immediate and delayed recall (Strauss, Sherman & Spreen, 2006).

Attention/working memory - the Paced Auditory Serial Addition Test (PASAT) is intended to measure attention deficits including concentration, speed of processing, mental calculation, and mental tracking. It is sensitive for diagnosing cognitive impairment in individuals above the age of 16.

The Spatial Span adapted from Wechsler's Memory Scale – third edition has 10 cubes in which the participant is required to follow a sequence of tapping the blocks both forwards and backwards.

Screening Test – was Hiscock Memory Test. The test has been designed to clinically identify an individual thought to be malingering. The participant is usually asked to remember some numbers and then asked to identify the set that the participants had seen.

3.5.2. Screening tests

Substance use and Chinese Substance Use History

The questionnaire contains a list of drugs and alcohol and the examinee is required to state which ones and how much they had used in the last three months. These questionnaires further require the examinee to state the quantities in details for each substance that was misused.

Patient`s Assessment of Own functioning

The questionnaire assesses an individual`s own functioning and provides information on any of the problems that an individual might be having in their daily living. It provides an opportunity for the participants to express how they have been feeling lately.

Activities of daily living

The questionnaire provides information on how well an individual is able to perform on common tasks like housekeeping, managing finances, buying groceries, cooking, planning social activities, understanding reading materials/TV, transportation, using the telephone, home repairs, bathing, dressing, shopping and others.

Reading level- the Zambia Achievement Test was used to measure reading abilities (Stemler, Chamvu & Chart, 2008).

3.5.3. Nutritional assessment:

Case Definition: For the purposes of this study a case of adult malnutrition as a co-morbid is represented by BMI, serum protein, random blood glucose level and haemoglobin level. Serum protein, random glucose level and haemoglobin levels indicate a component of a balanced diet. The energy is derived from all of them (carbohydrates, proteins and fats) (Mclaren, 1981).

Anthropometric and biomedical measurement

The Quetelet`s index the most widely used height – weight index is commonly referred to as BMI and it is a validated measure for nutritional status (Mahan & Escott – Stump, 2008). BMI calculation requires weight and height measurements and based on these results, it can indicate whether an individual is malnourished or not. BMI provides a good reflection of the energy status of adults and is calculated as follows: BMI = Weight (kg) divided by height (metres squared). BMI less than 18.5 is defined as under-nutrition, 18.5 to 24.9 defined as normal weight, 25 to 29.9 – obese, greater than 30 – obese (Zambia Demographic Health Survey, 2007) . These are the four categories that were used to define nutritional status of a participant.

Serum total protein

Serum protein is used to diagnose, evaluate and monitor the course of a disease in patients with protein state wasting, impaired nutrition and many others. Serum protein is a combination of prealbumin, albumin and globulin. Albumin is an indirect measure of nutrition. Globulin is a key building block of antibodies, glycoproteins, lipid proteins and clotting factors. Malnourished individuals usually have a decreased level of serum protein. Reference range is from 68.4 – 83.9 (Pagana & Pagana, 2002).

Glucose level

It is basic single sugar in the body metabolism. It is a form of sugar that circulates in the blood and supplies the primary fuel or energy for the body. It is used in the evaluation of diabetes, in such cases it is usually high. It is usually low in fasting state and starvation. In this study only random blood glucose was assessed. The reference range is from 3.88 – 5.6 mmol/l.

Haemoglobin level

Hemoglobin consists of two components- globin (protein) and haem (iron). The various types of globin combine with haem to form different haemoglobin. It is also a measure of total amount of Hgb in blood. It is a more direct measure of iron deficiency because it quantifies total Hgb in red blood cells. It is usually low in cases of anaemia,

overhydration and deficiency. The reference ranges for the males is from 13.0 g/ dl to 17.0 g/dl and for females it is from 10.9 – 17.3 g/ dl. The critical value is less than 7g/dl.

Dietary questions

The general socio-demographic questionnaire contained information on some of the psychosocial factors that might lead to poor nutrition in HIV positive adults.

3.6. Data Analysis

The collected data was analyzed with the help of Statistical Package for Social Sciences (SPSS no 15.0).

1) Descriptive Analyses were performed for the independent and selected dependent variables to obtain means and standard deviations.
2) To determine whether malnutrition as a co-morbid factor affects neurocognitive performance, hierarchical multiple regression was used.
3) To identify which neurocognitive domains are more affected by malnutrition as a co-morbid factor in HIV positive adults, Multivariate Analysis of Variance (MANOVA) was used.
4) To determine whether both gender and nutritional status have an effect on neurocognitive performance Multivariate Analysis of Variance (MANOVA) was used.
5) T-score and ANOVA was also used for further data analysis.

T-scores and deficit scores used to determine levels of functioning. T-scores were developed to facilitate interpretation of test results by allowing the comparison of a young person's scores against norms from an equivalent age and gender group. T-scores are standardized scores that are calculated from the total distribution of scores within the sample. T- Scores have a mean of 50 and a standard deviation of 10. Scores one standard deviation above the mean are considered to be in the normal range. As for domain deficit scores- a score above 0.5 is considered to be cognitively impaired. A deficit score less than 0.5 is considered to be functioning normally.

CHAPTER FOUR

4. RESULTS

4.0. Response rate

The study had managed to capture a total of 324 HIV positive participants. For this study only data from 263 participants were considered. Some participants were not considered because their data on the WSCT and Category tests were lost.

4.1. Characteristics of the sample

The sample consisted of 263 participants. The pie chart below shows the distribution of gender. From the total number of participants, 40.7% were males and 59.3 % were females. They were more females than males.

Figure 1. Pie chart showing the distribution of gender

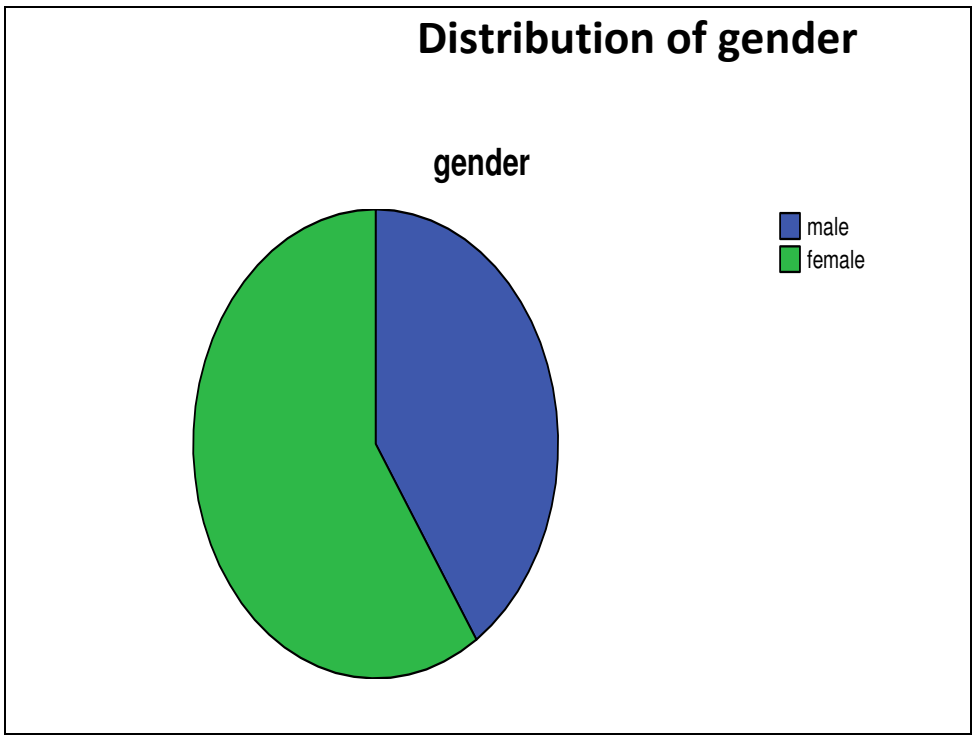


Figure 2. Bar chart showing years of education

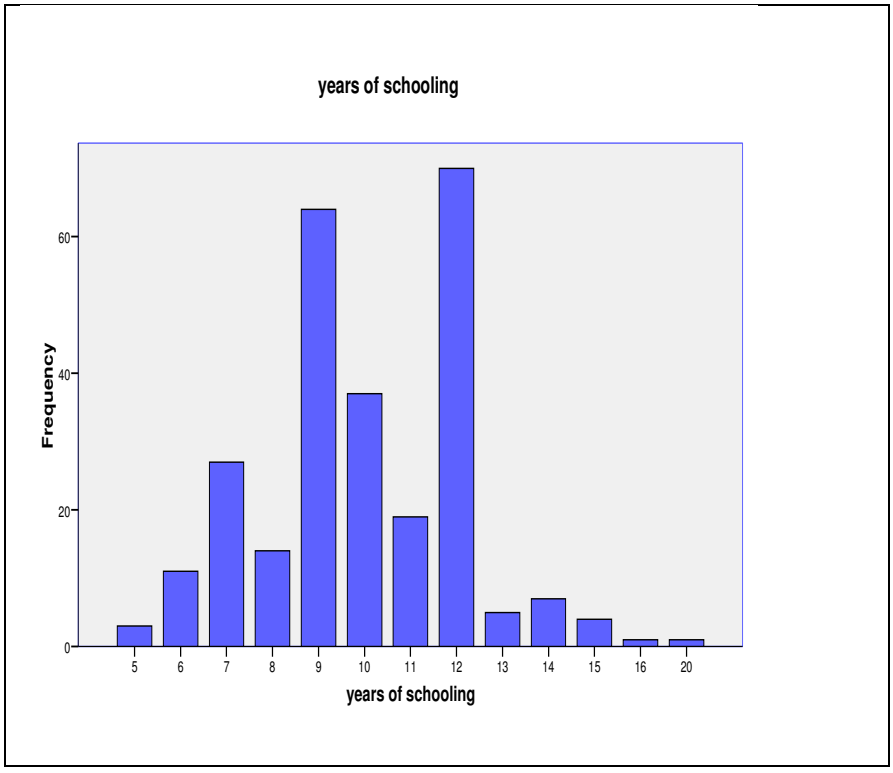
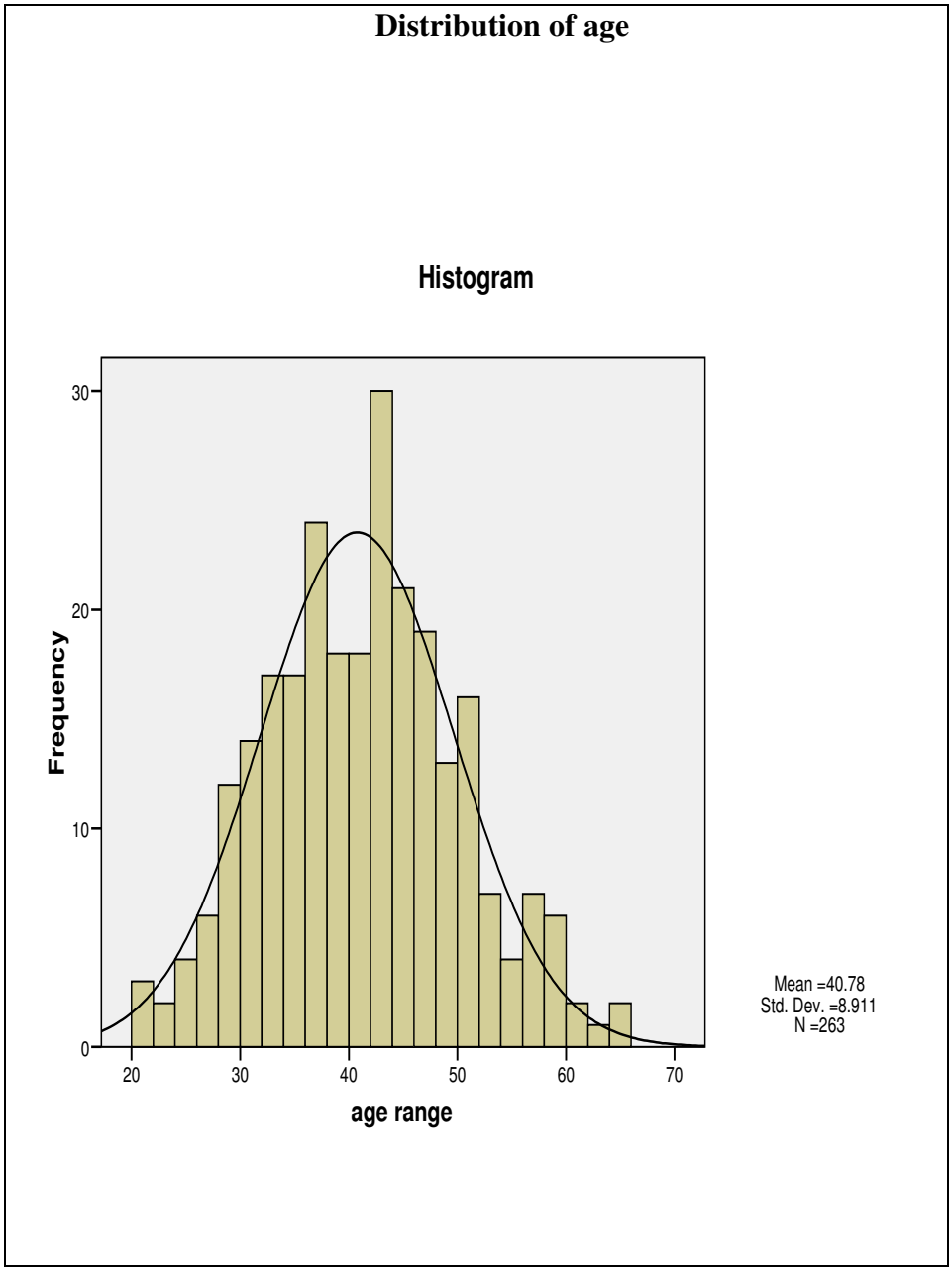


Figure two shows the sample`s distribution of education. Levels of education ranged from 5 to 20 years. It can be observed from the bar chart that the highest reported level of education was 12 years, followed by 9 years of education. The lowest reported numbers were 16 and 20 years of education.

Figure 3. Histogram showing distribution of age



The histogram above shows the distribution of the variable of age. From the figure the ages ranged from 20 to 65. Ages were categorised into five groups. The highest obtained number for the variable of age was from 30 to 40 years and 40 to 50 years.

Table 1. Employment status

	Frequency	Percent (%)
Employed	116	45.1
Unemployed	141	54.9

The tables above shows that 141 (54.9%) participants were unemployed and only about 116 (45.1%) participants were employed bringing the total to 257 due to missing data.

Data that was obtained from the general questionnaire indicate that about 235 (92.2%) participants had received advice on nutrition from the health center after testing for HIV and only 20 (7.8%) participants indicated that they did not receive any advice on nutrition from their respective health centres (N = 255 due to 8 missing data). From the 235 participants who received nutritional advice, 133 (56.4%) indicated that they followed nutritional advice and 102 (43.5%) participants indicated that they did not follow the advice that they got from the health centre. The data also showed that most participants did not follow nutritional advice because they lacked money to buy prescribed food (83.3%). The data also demonstrates that most of the participants` managed to eat more than three meals per day (63.5%). It also indicates that the quality of food for most participants was not plenty (12.9%) but just enough. The data also shows that most of the participants had consumed more than 5 cups/glasses of fluids (58.4%) per day.

Table 2. Global Deficit score impairment.

For the deficit score, impairment cut score is above 0.5. A deficit score below 0.5 is considered to be normal in terms of cognitive functioning.

	Frequency	Percent (%)
Not impaired	176	66.9
Impaired	87	33.1

The table above shows that of the 263 participants, 176 (66.9%) were not impaired and only 87 (33.1%) were impaired.

Table 3. Levels of nutritional variables and CD4 count, WHO staging, ART.

Variables	**BMI**			**Glucose**		
	Low **n = 25**	**Medium** **n = 171**	**High** **n = 48**	**Low** **n=26**	**Medium** **n=189**	**High** **n=41**
CD4	Lo-4 Norm-19	Lo-51 Norm-118	Lo-10 Norm-36	Lo-3 Norm-20	Lo-48 Norm-139	Low-8 Norm-30
WHO staging	S1-2 S2- 5 S3- 7	S1-42 S2-27 S3-56 S4-6	S1-13 S2-5 S3-8 S4-2	S1-3 S2-7 S3-9	S1-39 S2-30 S3-60 S4-6	S1-10 S2-4 S3-9 S4-1
ART	Y -23 N-5	Y-161 N-10	Y-36 N-7	Y-24 N-2	Y- 175 N-13	Y-37 N-3

Lo=low, norm = normal, S= stage, Y= yes, N=no

Table 4: Levels of nutritional variables and CD4 count, ART, and WHO staging.

Variables	**Protein**			**Haemoglobin**		
	Low **n= 9**	**Medium** **n= 175**	**High** **n=72**	**Low** **n=62**	**Medium** **n=191**	**High** **n=3**
CD4	Lo-8 Norm-1	Lo-20 Norm-150	Low-10 Norm38	Low-4 Norm-14	Lo-45 Norm-100	Lo-0 Norm-3
WHO staging	S1-2 S2-2 S3-5	S1-35 S2-28 S3-65 S4-8	S1-13 S2-14 S3-30 S4-6	S1-18 S2-6 S3-38	S1-10 S2-20 S3-110 S4-4	S1-0 S2-0 S3-3
ART	Y-7 N-2	Y-160 N-10	Y-62 N-7	Y-61 N-1	Y-176 N-15	Y-3 N-0

Lo=low, norm = normal, S= stage, Y= yes, N=no

The comparison tables above shows the four variables of nutrition and CD4 count, ART and WHO disease stages. A number of participants had normal CD4 count, most of them were ART and majority had a WHO disease stage of 3. Only three indicators were used to make comparisons because most of the data for the other indicators were missing.

Table 5. Levels of nutritional variables (BMI and glucose) and gender.

Variable	BMI Low n= 27	BMI Normal n= 172	BMI High n=47	Glucose Low n= 27	Glucose Normal n=190	Glucose High n=44
Male	17	80	5	9	84	9
Female	10	92	42	18	106	35

The table above indicates that most of the participants had normal levels of BMI and Glucose. The table also shows that most female participants had high BMI (n= 42) as compared to the male participants (n = 5). The table also shows that a number of male participants had low BMI (n =17).

As for glucose the results in that table show that a number of females participants had high levels of Glucose (n=35) as well low levels of glucose (n=18) as compared to the male participants.

Table 6. Levels of nutritional variable (haemoglobin and protein) and gender

Variable	**Hb Low n= 63**	**Hb Normal n= 167**	**Hb High n=3**	**Protein Low n=76**	**Protein Normal n= 114**	**Protein High n=71**
Male	**38**	**39**	**3**	**5**	**72**	**30**
Female	**24**	**129**	**0**	**4**	**109**	**41**

Hb- haemogblobin

The table above indicates that most of the participants had normal levels of haemoglobin and Protein. The table also shows that a number of male participants had low levels of haemoglobin (n= 38) as compared to the female participants (n = 24).

It also indicated that a number of participants had high levels of protein (males = 30, females = 41).

Table 7. Two nutritional variables and T-scores for all ability domains and global mean T-scores

Variables	**Hb lo n = 62**	**Hb normal n= 192**	**Hb High n= 3**	**Protein Low n=9**	**Protein Normal n= 177**	**Protein High n= 73**
Global mean T-score	44.63	46.76	51.01	46.87	46.38	44.75
SIP mean T-score	41.87	46.52	48.19	43.38	42.56	46.38
Learning mean T	41.25	46.63	56.25	44.94	45.17	43.45
Motor mean T scores	43.63	54.19	54.57	54.97	51.16	33.63
Recall mean T Score	38.35	47.53	54.47	42.86	44.85	49.05
Workinmemory mean T score	41.72	44.85	46.96	44.01	47.19	44.09
Fluency mean T score	48.73	47.47	50.86	48.39	51.51	46.26
Executive function Mean T score	37.31	48.70	50.59	39.35	44.76	41.12

Table 8. Two nutritional variables and T-scores for all ability domains and global mean T-scores.

Variables	Glucose low n = 26	Glucose normal n= 191	Glucose High n=41	BMI Low n=25	BMI Normal n= 171	BMI High n= 48
Global mean T-score	45.24	45.94	47.52	45.20	46.17	47.47
SIP mean T-score	44.34	45.37	46.93	45.82	45.43	47.28
Learning mean T score	44.92	44.68	46.28	41.39	45.92	45.72
Motor mean T score	50.91	38.49	43.32	48.95	46.12	42.50
Recall mean T score	45.48	47.48	36.74	32.62	38.86	45.48
Working memory mean T score	52.09	44.08	46.49	41.18	37.53	48.99
Verbal fluency mean T score	45.49	49.38	51.51	48.39	43.38	45.53
Executive function mean T score	50.15	44.30	47.82	32.12	47.02	49.07

Table 7 and 8 shows the four nutritional variables, with the three columns indicating low, normal and high nutritional levels (and the ns associated with each) and the rows indicates mean T-scores for each ability domains (motors, Speed of Information Processing , Recall , Learning, Working Memory, Verbal Fluency, and Executive Functioning) and global mean T – scores.

4.2. Means and standard deviations

The figures below show means and standard deviations of selected independent variables. These are variables that represent the variable of malnutrition and these are BMI, protein, glucose and haemoglobin.

Figure 4: Means and Standard deviations for the variable of BMI.

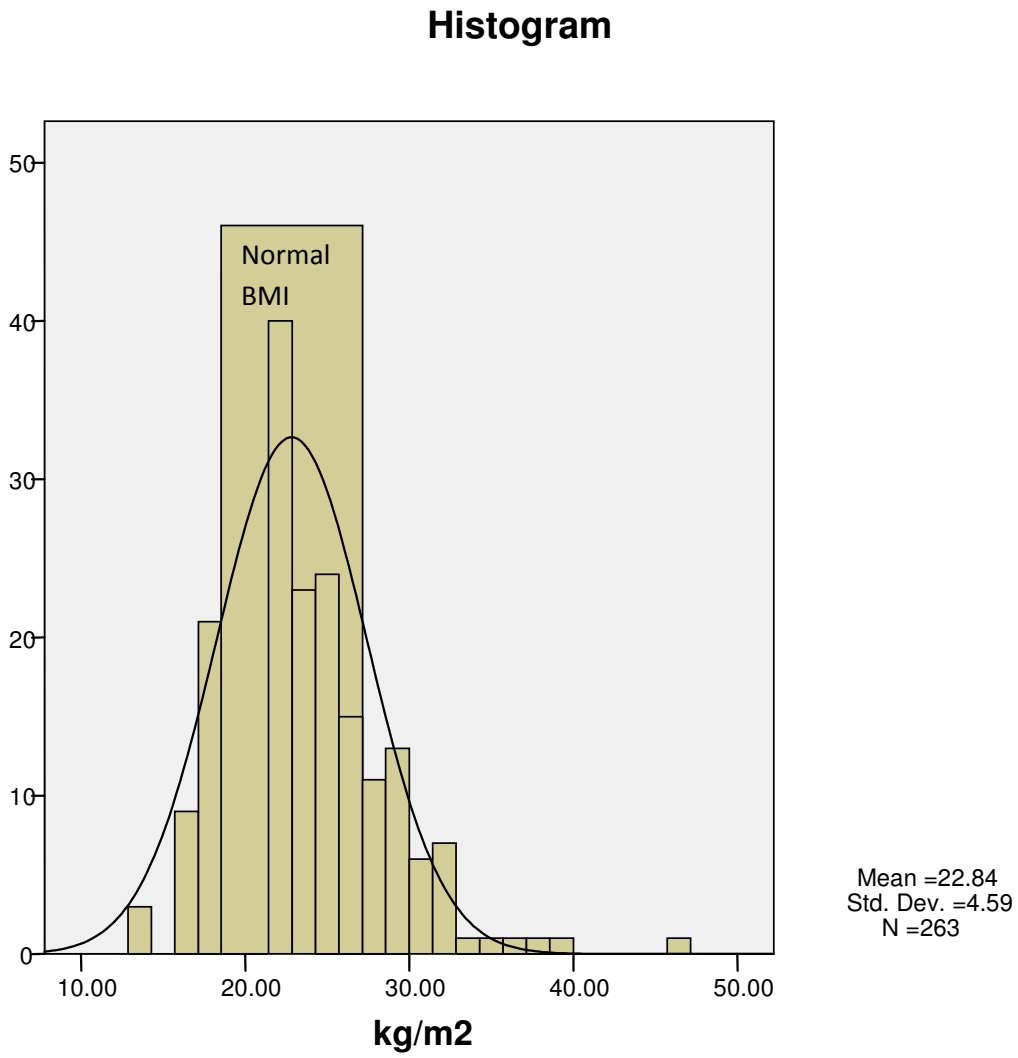


Figure four shows BMI scores with a mean of 22.83 and a standard deviation of 4.59 with N= 263. The figure shows that majority of the participants clustered around the mean. This simply means that most of the people had a normal Body Mass Index. Individuals who were underweight were 25 (9.5%), normal weights were 171 (65%), overweight were 48 (18.3%) and obese were 19 (7.2%).

Figure 5: Means and standard deviation for the variable of haemoglobin.

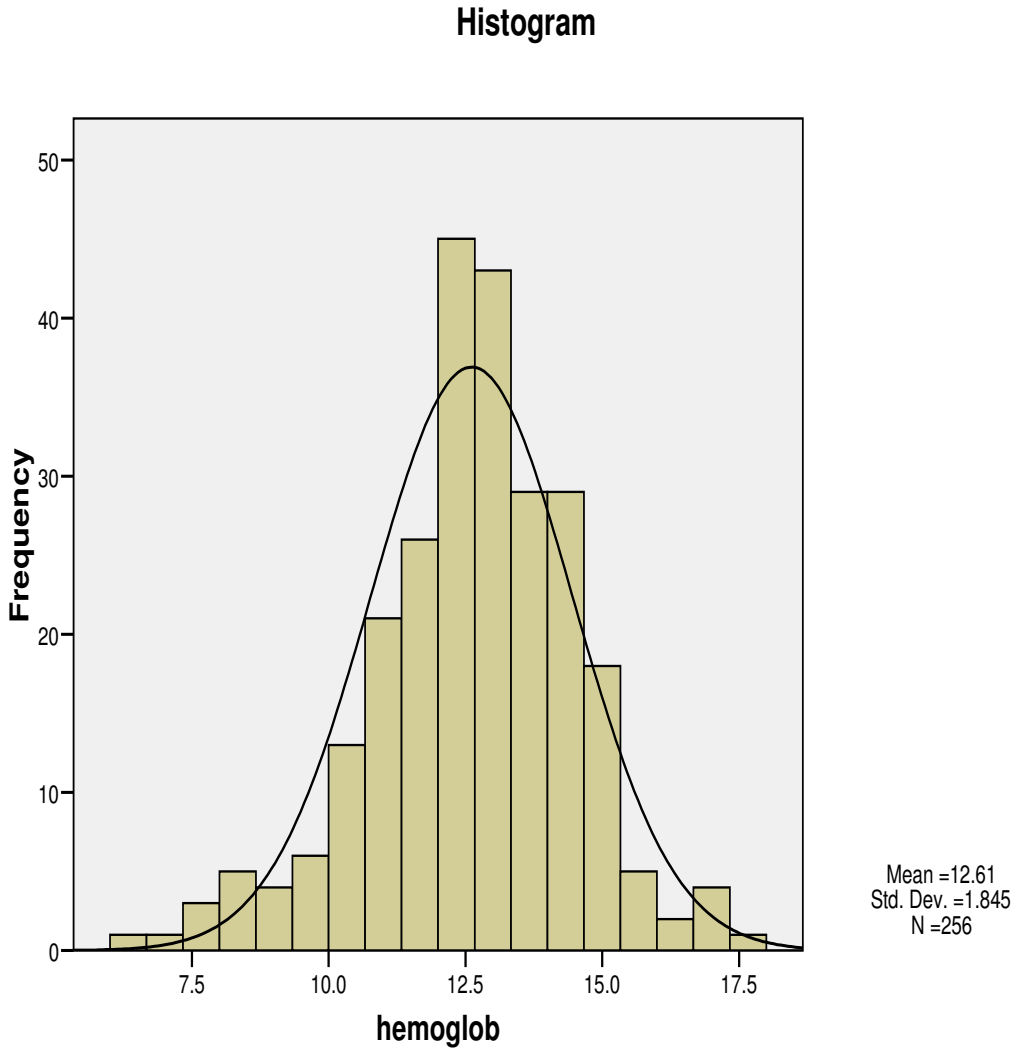


Figure five shows scores on hemoglobin with a mean of 12.61 and a standard deviation of 1.85 with N = 256 due to 7 missing variables in the sample. The figure shows that a number of participants had normal levels of haemoglobin.

Figure 6: Means and standard deviation for the variable of protein.

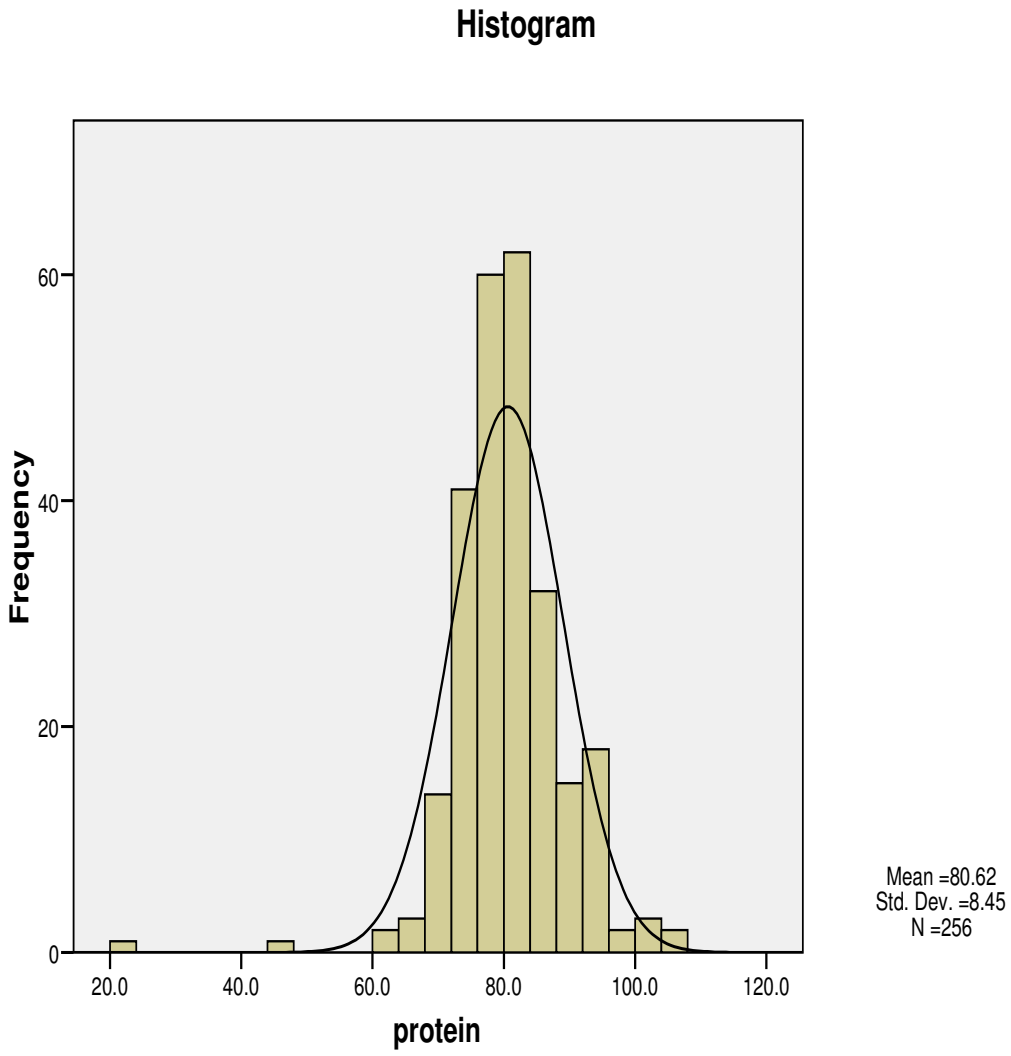


Figure six shows data that was obtained when the participants` levels of protein in the blood was analysed. The figure shows a mean of 80.62, a standard deviation of 8.45 with N = 256 due to missing data in the sample. The figure also shows that majority of the participants had normal levels of protein in the blood.

Figure 7: Means and standard deviation for the variable of glucose.

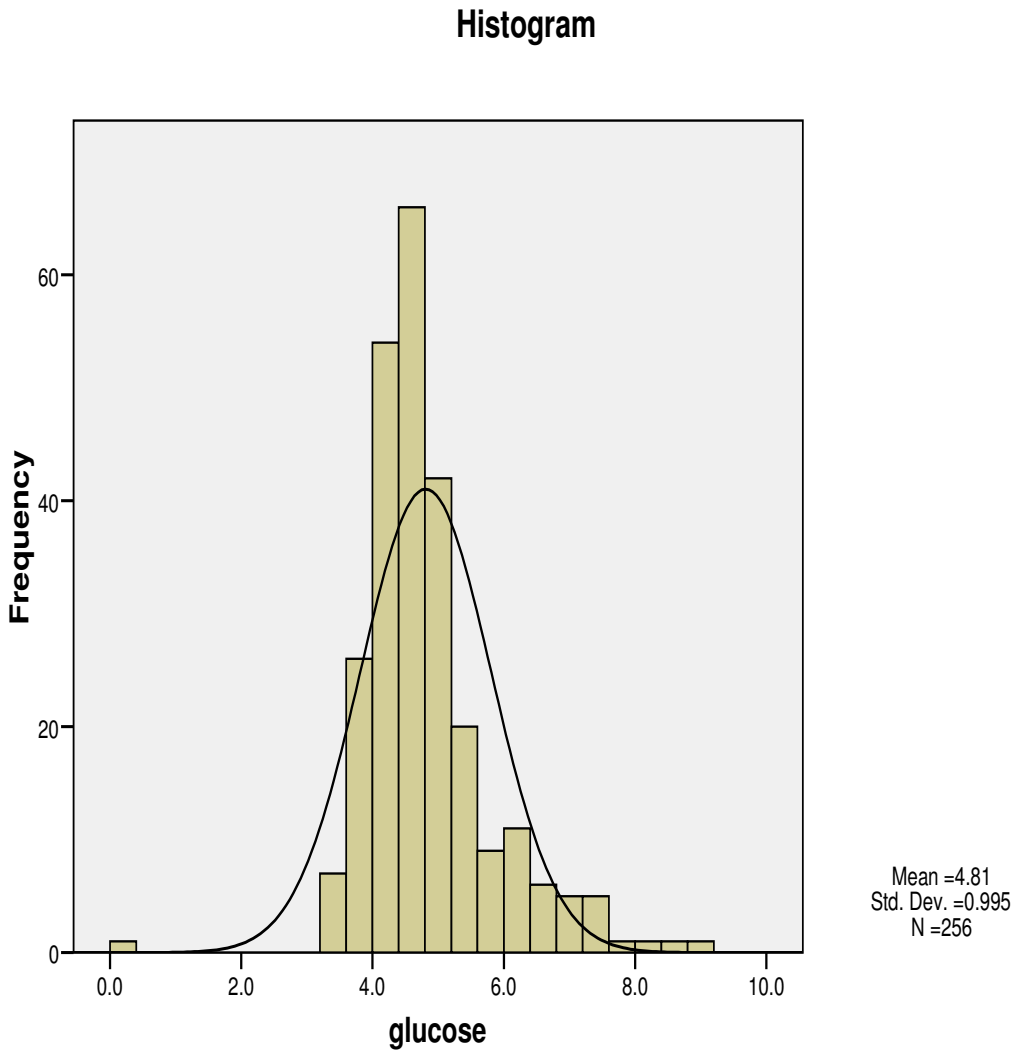


Figure seven shows raw scores on glucose with a mean of 4.81 and a standard deviation of 0.955, with a total number of 256 participants due to missing variables in the sample. The figure shows that majority of the participants clustered around the mean. This simply means that a number of participants had normal levels of glucose.

Before the data was analysed further, it was explored to determine the relationship between the dependent variables (global T- mean score) and the independent variables in this case BMI, heamoglobin, glucose and protein. The relationship between the

independent variables and neurocognitive functioning was investigated using Pearson product moment correlation coefficient. The explored data showed that there was a non weaker relationship between: BMI and neurocognitive functioning, r = 0.10, N = 263; Glucose and neurocognitive functioning, r = 0.083, N = 256; between protein and neurocognitive functioning, r = - 0.068, N = 256 and heamoglobin r = 0.218, N = 256 (significant at 0.01 2 tailed). From the corrections obtained it can be noted that low nutrition is associated with poorer cognitive functioning especially in low haemoglobin states.

4.3. Effects of malnutrition as a co-morbid factor on neurocognitive performance in HIV positive adults.

For the purposes of this study a case of adult malnutrition as a co-morbid factor is represented by BMI, serum protein, random blood glucose level and haemoglobin level.

In order to determine the effects of malnutrition as a co-morbid factor on neurocogntive test performance hierarchical multiple regression analysis was used for continuous independent variables, one - way between analysis of variance ANOVA was also used for categorical variables. The independent variables were entered in the equation in an order specified by the researcher. The variables were entered in the following order: (1) BMI, (2) total protein, (3) glucose and (4) haemoglobin. The variables were entered in this manner because the researcher wanted to determine the effects of each variable of malnutrition on the dependent variable, which in this case is neurocognitive test performance. In this method the relative contribution of each set of variables is also assessed. The variables were also entered in this manner because the researcher thought that BMI index would account for a significant portion of the variance as compared to other variables. BMI was the primary indicator for malnutrition but the researcher decided to look at the variables independent of each other.

Table 9. Hierarchical regression analysis to determine the effects of malnutrition. (BMI, protein, glucose and haemoglobin) on the global mean- T scores (these are mean- T scores obtained after combining various neuropsychological tests mean – T scores).

Variables	**B**	**SE**	**β**	**P**
BMI	0.189	0.127	0.100	0.139
Protein	**-**0.040	0.044	-0.061	0.364
Glucose	0.433	0.378	0.078	0.254
Hemoglobin	0.614	0.202	0.204*****	0.003*****
	Model 1	**Model 2**	**Model 3**	**Model 4**
R^2	0.010	0.014	0.020	0.060
ΔR^2	0.010	0.004	0.006	0.040
F	2.204	1.515	1.448	4.219*****
ΔF	2.204	0.827	1.310	9.252*****

***P< 0.05** SE = standard error, β= beta weight, ΔF **=** F change, p= significant, R = variance, the p – values in model 1 represents only Body Mass Index (BMI), model 2- protein, model 3 – glucose and model 4 haemoglobin only. Each nutritional variable has its own p value in all the 4 models.

The table indicates the effects of malnutrition as a co-morbid factor on neurocognitive functioning. From the regression, model 4 (which includes BMI, protein, glucose and haemoglobin basically all the variables) is significant. The whole model explains 6.0 percent of the variance ($R^2 = 0.060$, $F(4,219) = 3.440$, $p < 0.05$). The variance includes all the variables from all the models. Haemoglobin

levels accounted for a significant portion of the variance in model 4 ($\Delta R^2 = 0.040$, $\Delta F = 9.252$, $p< 0.05$). It is can also be noted that haemoglobin has the strongest relationship with global mean T-scores ($\beta = 0.204$, $p<0.05$). This simply means that variable of malnutrition as a co-morbid factor, especially in haemoglobin states, has an effect on global mean T scores. None of the models (1, 2, and 3) were statistically significant. This means that the other three variables (BMI, glucose, protein) contributions to the overall variance were very small.

Table 10. One - way between groups analysis of variance (ANOVA) was conducted to determine the effects of malnutrition as a co-morbid factor on global mean T-scores (neurocognitive functioning). In table 3 the variables (BMI, protein, glucose and haemoglobin) that were used to determine malnutrition as a co-morbid factor were used as continuous variables, in this case they were used as categorical variables.

Global mean T scores

Effect	F	P
BMI	1.732	0.179
Protein	2.053	0.130
Glucose	1.416	0.245
Hemoglobin	5.588	0.004

F=ratio of mean square, p- value= significant

ANOVA was conducted to determine the effects of malnutrition as a co-morbid factor on neurocognitive test performance. All the variables that represented the independent variable (BMI, glucose, protein and haemoglobin) were divided into 3 groups (group 1- normal, group 2 – high and group 3 – low). The above table indicates that there is no statistically significant difference in neurocognitive test

performance for BMI (F (2,262) = 1.732, p = 179), protein (F (2,255) = 2.053, p = 0.130) or glucose (F (2,255) = 1.416, p = 0.245). As for haemoglobin, the table shows that there is a statistically significant difference on neurocognitive test performance for the 3 levels of haemoglobin: F (2,255) = 5.588, p = 0.004. In order to determine actual difference in mean scores, Post Hoc Tukey was performed. Post Hoc Tukey indicated that the mean scores for group 1 (normal levels of haemoglobin) (Mean sample size = 8.458, SD= 5.264) was statistically significant from group 3 (low levels of haemoglobin) (Mean sample size = 8.458, SD = 5.789). Group 3 performed lower than group 3 on dependent variable. Group 3 (high levels of haemoglobin) (Mean sample size = 8.458, SD=5.493) did not differ significantly from group 1(mean sample size = 8.458, SD = 5.264, p = 0.409) and group 3 (mean sample size = 8.458, SD = 5.789, p = 0.114).

4.4. Effects of malnutrition as a co-morbid factor on individual neurocognitive domains in HIV positive adults.

For the purposes of the current study a case of adult malnutrition as a co-morbid factor is represented by BMI, serum protein, random blood glucose level and haemoglobin level

In order to determine which neurocognitive domains are most affected by malnutrition as a co-morbid factor in HIV positive adults, Multivariate Analysis of Variance (MANOVA) was used. MANOVA combines the information from the dependent variables (in this case it is individual tests scores) into a composite variable. MANOVA was run for each neurocognitive domain using tests within each domain. Scores representing participants` ART statuses were also run in MANOVA as a covariate. ART was corrected for because some participants were on ART and some were not.

Table 11. MANOVA to determine which neurocognitive domains are affected by different categories of BMI.

	Body Mass Index			
Domain	**Value**	**F**	**η^2**	**P**
Executive functioning	0.986	0.612	0.007	0.721
Verbal fluency	0.980	0.883	0.010	0.507
Motor dexterity	0.955	0.331	0.003	0.857
SIP	0.952	1.272	0.024	0.243
Working memory	0.987	0.872	0.007	0.481
Recall	0.983	1.098	0.008	0.357
Learning	0.962	2.535	0.019	0.039

P =significant, $\boldsymbol{\eta^2}$= effect size

MANOVA was used to determine which neurocognitive domains are more affected by malnutrition as a co-morbid factor. In table 5, MANOVA combined information from individual test mean T- scores into a new composite variable for each neurocognitive domain, these include executive functioning (Wisconsin card Sorting

Test, Halstead category Test, stroop colour- word), verbal fluency (controlled oral word association (FAS), category fluency tests (animal and action naming), motor dexterity (grooved pegboard dominant and non dominant hands), SIP (digit symbol, symbol search, trail making Part A, colour trails - Part 1), working memory (PASAT and spatial span), learning and recall (HVLT-R, BVMT-R). BMI was run on all seven composite variables. The results in the table show that MANOVA was not statistically significant, $p > 0.05$ for most domains. The domains that did not indicate a significant p value are as are as follows: executive functioning, verbal fluency, motor dexterity, SIP, working memory and recall. For these domains Wilks' Lambda`s values ranged from 0.952 to 0.986; eta squared also ranged from 0.003 to 0.024. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a minimum effect. The values represent about 2.4 per cent to 0.3 percent of the total variance. The table also indicates that the only domain that resulted in a significant p-value was learning $F(2,262) = 2.535$, $p = 0.039$, Wilk`s Lambda = 0.962, partial eta squared = 0.019. Further analysis indicates that there is a statistically significant difference on learning: $F(2,262) = 4.784$, $p = 0.009$. In order to determine actual difference in mean scores, Post Hoc Tukey was performed. Post Hoc Tukey indicated that mean scores for group 1 (normal levels of BMI) ($M = 44.39$, $SD = 9.139$) was lower and statistically different from group 2 (high levels of BMI) ($M = 47.76$, $SD = 9.213$). As for group 3 (low levels of BMI) ($M = 41.88$, $SD = 8.168$) the mean score statistically differed from group 2 and was not statistically different from group 1. It was not expected that BMI will show a linear relationship since both high and low scores on the BMI are considered unhealthy.

Table 12. MANOVA to determine which neurocognitive domains are affected by different categories of protein.

	Protein		
Domain	**Value**	**η^2**	**P**
Executive functioning	0.956	0.022	0.183
Verbal fluency	0.954	0.024	0.062
Motor dexterity	0.992	0.004	0.722
SIP	0.973	0.014	0.740
Working memory	0.984	0.008	0.388
Recall	0.985	0.008	0.432
Learning	0.968	0.016	0.082

P =significant, $\boldsymbol{\eta^2}$= effect size

In the table above MANOVA combined information from individual test mean T- scores into a new composite variable for each neurocognitive domain, these include executive functioning (Wisconsin card Sorting Test, Halstead category Test, stroop colour- word), verbal fluency (controlled oral word association (FAS), category fluency tests (animal

and action naming), motor dexterity (grooved pegboard dominant and non dominant hands), SIP (digit symbol, symbol search, trail making Part A, colour trails - Part 1), working memory (PASAT and spatial span), learning and recall (HVLT-R, BVMT-R). Different categories of protein were run on all seven composite variables. The results in the table show that MANOVA was not statistically significant, $p > 0.05$ for the seven domains. This simply means that different categories of protein did not affect any of the seven neurcognitive domains. Since MANOVA is not significant for all the seven domains there is no need for further analysis. Wilks' Lambda`s values ranged from 0.954 to 0.984; eta squared also ranged from 0.008 to 0.024. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a minimum effect. The values represent about 2.4 per cent to 0.8 percent of the total variance.

Table 13. MANOVA to determine which neurocognitive domains are affected by different categories of glucose.

	Glucose			
Domain	**Value**	**F**	η^2	**P**
Executive functioning	0.992	0.251	0.004	0.980
Verbal fluency	0.943	2.501	0.029	0.022
Motor dexterity	0.990	0.639	0.005	0.635
SIP	0.946	1.744	0.027	0.086
Working memory	0.991	0.546	0.004	0.702
Recall	0.972	1.820	0.014	0.124
Learning	0.989	0.704	0.014	0.124

P =significant, η^2= effect size

In the table above, MANOVA combined information from individual test mean T-scores into a new composite variable for each neurocognitive domain, these include executive functioning (Wisconsin card sorting Test, Halstead category test, stroop colour- word), verbal fluency (controlled oral word association (FAS), category

fluency tests (animal and action naming), motor dexterity (grooved pegboard dominant and non dominant hands), SIP (digit symbol, symbol search, trail making Part A, colour trails - Part 1), working memory (PASAT and spatial span), learning and recall (HVLT-R, BVMT-R). Different categories of glucose were run on all seven composite variables. The results in the table show that MANOVA was not statistically significant, $p > 0.05$ for the six domains of executive functioning, motor dexterity, SIP, working memory, recall and learning. This simply means that different categories of glucose did not affect any of the six neurcognitive test domains. Since MANOVA for these domains, there is no need for further analysis. Wilks' Lambda`s values ranged from 0.943 to 0.992; eta squared also ranged from 0.004 to 0.027. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a minimum effect. The values represent about 2.7 per cent to 0.4 percent of the total variance. As for verbal fluency, the table indicates that MANOVA is statistically significant. This simply means that the there is an effect of glucose on this particular domain, $F(2,253) = 2.501$, $p = 0.022$, Wilk Lambda = 0.943, partial eta squared = 0.029. Further analysis indicated that there was no difference in mean for glucose. The mean for all three groups of glucose was not statistically significant (group 1: FAS – M = 46.11, SD = 10.415; animal naming – M = 48.07, SD = 10.313; Action naming – M = 45.76, SD = 10.742. Group 2: FAS - M = 45.34, SD = 11.103; animal naming – M = 51.73, SD = 9.902; Action naming – M = 45.59, SD = 10.315. Group 3: M = 43.27, SD = 12.911; animal naming – M = 48.85, SD = 10.410; Action naming – M = 39.69, SD = 9.649.

Table 14. MANOVA to determine which neurocognitive domains are affected by different categories of hemoglobin.

	Haemoglobin			
Domain	**Value**	**F**	***η²***	**P**
Executive functioning	0. 933	2.198	0.034	0.026
Verbal fluency	0. 959	1.750	0.021	0. 108
Motor dexterity	0.995	0.331	0.003	0.857
SIP	0. 966	1.084	0.017	0. 373
Working memory	0.987	0.872	0.007	0.481
Recall	0. 958	2.734	0.021	0.028
Learning	0.930	4.668	0.036	0.001

P =significant, η^2= effect size

In the table, MANOVA combined information from individual test mean T- scores into a new composite variable for each neurocognitive domain, these include executive functioning (Wisconsin card sorting test, Halstead category test, stroop colour- word), verbal fluency (controlled oral word association (FAS), category

fluency tests (animal and action naming), motor dexterity (grooved pegboard dominant and non dominant hands), SIP (digit symbol, symbol search, trail making Part A, colour trails (Part 1), working memory (PASAT and spatial span), learning and recall (HVLT-R, BVMT-R). Scores on haemoglobin were run on all seven composite variables. The results in the table show that MANOVA was not statistically significant, $p > 0.05$ for four neurocognitive domains domains. The different groups of haemoglobin did not affect the four neurcognitve domains. The domains that were not affected by malnutrition as measured by haemoglobin are as follows: verbal fluency, motor dexterity, SIP and working memory. For these domains Wilks' Lambda`s values ranged from 0.959 to 0.995; eta squared also ranged from 0.003 to 0.021. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a minimum effect. The values represent about 2.1 per cent to 0.3 percent of the total variance. Since MANOVA is not significant for the four domains there is no need for further analysis. The table also indicates that there was a statistically significant differences among the different categories of haemoglobin dependent variables and these are learning $F (2,259) = 4.668$, $p = 0.001$, Wilk Lambda =0.930, partial eta squared = 0.036, executive functioning $F (2,259) = 2.198$, $p = 0.026$, Wilk Lambda = 0.933, partial eta squared = 0.034 and recall $F (2,259) = 2.734$, $p = 0.028$, Wilk Lambda = 0.958, partial eta squared = 0.021. Since MANOVA is significant there is need for further analysis. Upon further analysis it was determined that all mean scores from the 3 categories of haemoglobin differed significantly on all the domains (Learning: group 1: HVLT – M = 46.08, SD = 8.731; BVMT - M = 44.26, SD = 9.904. Group 2: HVLT – 56.00, SD = 15.620; BVMT – M = 56.67, SD = 9.904. Group 3: HVLT – M = 41.52, SD = 9.122, BVMT – M = 41.97, SD = 10.951). The differences in means scores were actually significant. For group 1 the mean score was actually lower than group 2. As for group 3, the mean score was lower than the mean scores from group 1 and group 2. As for recall, mean scores in group 1 and group 2 different significantly. The mean score in group 1 was higher than mean score in group 3. The mean scores also differed significantly in group 2 and 3. Mean score in group 2 were higher than

mean score in groups 3. There was no statistically significant difference in means scores between group 1 and 2. (group1: HVLT – M = 46.68, SD = 9.747; BVMT - M = 45.12, SD = 9.779. Group 2: HVLT – 53.00, SD = 10.817; BVMT – M = 56.67, SD = 9.904. Group 3: M =43.65, SD = 8.895, BVMT – M = 56.00, SD = 11.269). Mean scores on the domain of executive functioning differed significantly in group 1 and group 3. In mean scores in group 3 were significantly lower than mean scores in group 1. Mean scores in group 2 did not differ significantly from group 1 and 3. It can be indicated that poor nutritional status is associated with poorer cognitive performance.

4.5. Effect of both gender and nutritional status on neurocognitive functioning in HIV positive adults.

In order to determine which whether the gender and nutritional status on neurocognitive test performance in HIV positive adults, Multivariate Analysis of Variance (MANOVA) was used. MANOVA combines the information from the dependent variables (in this case domain T scores) into a composite variable.

Table 15. MANOVA showing the effects of nutritional status and gender on neurocognitive test performance when domain mean T scores were used.

Variables	Value	η^2	P
BMI* gender	0.093	0.031	0.297
Protein*gender	0.064	0.032	0.310
Glucose*gender	0.032	0.016	0.886
Haemoglobin*gender	0.081	0.041	0.114

p = significant value η^2 = effect size.

Multivariate Analysis of Variance was performed to determine whether gender has an effect on the relationship between nutritional status and neurocognitive test

performance. Mean T scores on executive functioning, learning, recall, working memory, fluency, motor and speed of information processing (SIP) were used. Between subjects were gender and all variables of nutritional status (BMI, glucose, haemoglobin and protein). The results show that p value for the interaction between the variables of gender and nutritional status are not statistically significant. P in all the four categories was greater than 0.05. Since MANOVA is not significant there is no need to further look at the effects of the independent and dependent variables. Pillai's Trace and Wilks' Lambda`s values ranged from 0.093 to 0.032; eta squared also ranged from 0.016 to 0.041. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a very small effect. The values represent about 1.6 per cent to 4.1 percent of the total variance. Domain mean T scores were used in the table above so as to determine whether there will be any differences in the overall variance.

Table 16. MANOVA showing the effects of nutritional status and gender on neurocognitive test performance when domain deficit scores were used in the analysis.

Variables	**Value**	**η^2**	**P**
BMI* gender	0.094	0.031	0.279
Protein*gender	0.078	0.039	0.141
Glucose*gender	0.033	0.017	0.876
Haemoglobin*gender	0.037	0.037	0.241

p = significant value η^2 = effect size.

The table above highlights results that were obtained when Domain Deficits mean T scores namely executive functioning, learning, recall, working memory, verbal fluency, motor and SIP were entered in MANOVA as the dependent variables and between subjects used were gender and nutritional status (BMI, protein, glucose and

haemoglobin). The results also show that, p value for the interaction is greater than 0.05 meaning that the results are not significant for all the four categories. The lowest p value obtained was 0.141 and the highest was 0.876 that is on the variables of protein/ gender and glucose/gender respectively. Since MANOVA is not significant there is no need to further look at the effects of the independent and dependent variables. Pillai's Trace and Wilks' Lambda`s values ranged from 0.094 to 0.033; eta squared also ranged from 0.017 to 0.039. Partial Eta Squared represents the proportion of the variance in the dependent variables that can be explained by the independent variable. In this case the values represent a very small effect. The values represent about 1.7 per cent to 3.9 percent of the total variance. The results in tables 7 and 8 are similar.

4.6. Additional analysis

Table 17. Cognitive functioning of low BMI and normal BMI

Variables	**Low** **n = 25** **Mean (SD)**	**Normal** **n= 171** **Mean (SD)**	**t-score**	**p-value**
Global mean	4.52 (5.13)	4.61 (5.65)	-0.809	0.419

P> 0.05

An independent samples t- test was conducted to compare the global mean scores for the low BMI and normal BMI. There was no significant difference in scores for low BMI (M = 4.52, SD = 5.13) and normal BMI (M = 4.61, SD = 5.65); t (194) = -0.809, p = 0.419 (two – tailed).

Table 18. Cognitive functioning of low and normal glucose

Variable	Low n = 26 mean (SD)	Normal n = 189 mean (SD)	t-score	p=value
Global mean	4.52 (5.48)	4.64 (5.64)	-1.012	0.313

P> 0.05

An independent samples t- test was conducted to compare the global mean scores for the low glucose and normal glucose. There was no significant difference in scores for low glucose (M = 4.52, SD = 5.64) and normal glucose (M = 4.64, SD = 5.64); t (213) = - 1.012, p = 0.313 (two – tailed).

Table 19. Cognitive functioning of low and normal protein

Variable	Low n = 9 mean (SD)	normal n = 175 mean (SD)	t-score	p-value
Global mean	4.68 (6.46)	4.69 (5.30)	-0.026	0.980

p > 0.05

The table above shows that there was no significant difference in scores for low protein (M = 4.68, SD = 6.46) and normal protein (M = 4.69, SD = 5.30); t (182) = - 0.026, p = 0.980 (two – tailed).

Table 20. Cognitive functioning of low and normal haemoglobin

Variable	Low n = 62 mean (SD)	Normal n = 191 mean (SD)	t-score	p=value
Global mean	4.46 (5.78)	4.70 (5.26)	-3.005	0.003

$p<0.05$

The table above indicates that there was significant difference in scores for low haemoglobin (M = 4.46, SD = 5.78) and normal haemoglobin (M = 4.70, SD = 5.26); t (251) = - 3.005, p = 0.003 (two – tailed). In this case poor nutrition is associated with poorer cognitive functioning.

The other tables indicating different levels of nutritional status were not included reason been that the results obtained were similar to the results in tables 7, 8,9,10 and 11.

Table 21.1 Two-way between-groups ANOVA for Global mean T score, BMI and WHO staging.

Effect	F	p -Value
Main effect of BMI	0.002	0.998
Main effect of WHO staging	0.301	0.825
Interaction	0.357	0.877

A two way between group analysis of variance was conducted to determine the impact of BMI and WHO disease staging on global mean T-score. Participants were divided into 3 groups according to their levels of BMI. The interaction effect between BMI and WHO disease staging was not statistically significant, F (5,190) =0.357, p=0.877. The main effect for BMI, F= (2,190) = 0.002, p= 0.998, was not statistically significant. The main effect for WHO staging, F= (3,190) = 0.301, p=0.877, did not reach statistical significance.

Table 21.2 Two-way between-groups ANOVA for Global mean T score, BMI and ART.

Effect	**F**	**p –Value**
Main effect of BMI	1.328	0.267
Main effect of ART	0.585	0.445
Interaction	1.613	0.201

A two way between group analysis of variance was conducted to determine the impact of BMI and ART. Participants were divided into 3 groups according to their levels of BMI. The interaction effect between BMI and ART was not statistically significant, F (2,244) = 1.613, p=0.201. The main effect for BMI, F= (2,244) = 1.328, p= 0.267, was not statistically significant. The main effect for ART, F= (1,244) = 0.585, p=0.445, was not statistically significant.

Table 21.3 Two-way between-groups ANOVA for Global mean T score, BMI and CD4 count

Effect	F	p –Value
Main effect of BMI	0.565	0.569
Main effect of CD4	3.004	0.084
Interaction	3.097	0.047*

P=<0.05*

There was a statistically significant interaction effect of the levels of BMI and CD4, F (2,226) =3.097, p=0.047. However, the effect size was small (partial eta. squared=.027). Post hoc comparisons using Tukey HSD test showed that the mean scores for low BMI (M=4.48, SD=4.87), normal BMI (M =4.62, SD= 5.51) and high BMI (M=4.71, SD = 5.56) were not significantly different. Post hoc tests were not performed for CD4 count because there were fewer than 3 groups (low and normal CD4 count). The main effect for BMI F (2,226) = 0.565 p= 0.567 did not reach statistical significance. The main effect of CD4 was not statistically significant F (1,226) = 3.004, p=0.084.

Table 22.1 Two-way between –groups ANOVA for Global mean T-score, haemoglobin and ART.

Effect	F	p –Value
Main effect of haemoglobin	2.058	0.130
Main effect of ART	0.113	0.737
Interaction	0.003	0.954

A two way between group analysis of variance was conducted to determine the impact of haemoglobin and ART. Participants were divided into 3 groups according to their

levels of haemoglobin. The interaction effect between ART and haemoglobin was not statistically significant, F (2,256) = 0.113, p=0.954. The main effect for haemoglobin, F= (2,256) = 2.058, p= 0.130, was not statistically significant. The main effect for ART, F= (1,256) = 0.113, p = 0.737, was not statistically significant.

Table 22.2 Two-way between –groups ANOVA for Global mean T-score, haemoglobin and WHO staging.

Effect	**F**	**p –Value**
Main effect of haemoglobin	1.211	0.300
Main effect of WHO staging	0.186	0.906
Interaction	0.381	0.767

The table above shows that the interaction effect between haemoglobin and WHO disease staging was not statistically significant, F (3,205) =0.381, p=0.767. The main effect for haemoglobin, F= (2,205) = 1.211, p= 0.300, was not statistically significant. The main effect for WHO staging, F= (3,205) = 0.381, p=0.767, did not reach statistical significance.

Table 22.3 Two-way between –groups ANOVA for Global mean T-score, haemoglobin and CD4 count.

Effect	F	p –Value
Main effect of haemoglobin	4.592	0.011*
Main effect of CD4	2.338	0.128
Interaction	2.264	0.134

P=<.05*

The results in the table above indicate that the interaction effect between haemoglobin and CD4 was not statistically significant, F (1,243) =2.264, p=0.134. The main effect for haemoglobin, F= (2, 243) = 4.592, p= 0.011, was statistically significant. Effect size (Eta squared) = 0.037. Post-hoc comparisons using the Turkey HSD test indicated that the mean score for low haemoglobin (M=4.46, SD=5.78), was statistically different from normal levels of haemoglobin (M = 4.69, SD = 5.24). High level of haemoglobin (M = 4.87, SD = 5.44) did not differ from either of the other groups. The main effect for CD4, F= (1,243) = 2.338, p=0.128, did not reach statistical significance.

Table 23.1 Two-way between –groups ANOVA for Global mean T-score, protein and ART

Effect	F	p –Value
Main effect of protein	0.398	0.672
Main effect of ART	1.639	0.202
Interaction	0.499	0.608

The table above shows that the interaction effect between protein and ART was not statistically significant, F (2,256) =0.499, p=0.767. The main effect for protein, F= (2,256) = 0.398, p= 0.672, was not statistically significant. The main effect for ART, F= (1,256) = 1.639, p=0.202, did not reach statistical significance.

Table 23.2 Two-way between –groups ANOVA for Global mean T-score, protein and WHO staging

Effect	**F**	**p –Value**
Main effect of protein	1.138	0.323
Main effect of WHO staging	0.230	0.875
Interaction	0.607	0.695

The table above shows that the interaction effect between protein and CD4 count was not statistically significant, F (5,205) = 0.607, p=0.695. The main effect for protein, F= (2,205) = 0.230, p= 0.875, was not statistically significant. The main effect for WHO staging, F= (3,205) = 0.230, p=0.875, did not reach statistical significance.

Table 23.3 Two-way between –groups ANOVA for Global mean T-score, protein and CD4 count

Effect	**F**	**p –Value**
Main effect of protein	1.657	0.193
Main effect of CD4	7.568	0.006*
Interaction	3.520	0.031*

p=<0.05*

The results in the table above indicate that the interaction effect was statistically significant, F (2,243) =3.520, p=0.031. Effect size (Eta squared) = 0.037. Post-hoc comparisons using the Turkey HSD test indicated that the mean scores for low protein, normal levels of protein and high protein were not different. Post hoc tests were not performed for CD4 count because there were fewer than 3 groups. The main effect for protein, F= (2, 243) = 1.657, p= 0.193, was not statistically significant. The main effect for CD4 count, F= (1,243) = 7.568, p= 0.006 was statistically significant.

Table 24.1 Two-way between –groups ANOVA for Global mean T-score, glucose and ART

Effect	**F**	**p –Value**
Main effect of glucose	0.068	0.934
Main effect of ART	0.430	0.513
Interaction	1.210	0.300

The table above shows that the interaction effect between glucose and ART was not statistically significant, F (2,256) = 1.210, p=0.300. The main effect for glucose, F= (2,256) = 0.068, p= 0.934, was not statistically significant. The main effect for ART, F= (1,256) = 0.430, p=0.513, did not attain statistical significance.

Table 24.2 Two-way between –groups ANOVA for Global mean T-score, glucose and WHO staging.

Effect	**F**	**p –Value**
Main effect of glucose	0.088	0.916
Main effect of WHO staging	1.863	0.137
Interaction	1.628	0.141

The table above shows that the interaction effect between glucose and WHO staging was not statistically significant, F (6,204) = 1.628, p=0.141. The main effect for glucose, F= (2,204) = 0.088, p= 0.916, was not statistically significant. The main effect for WHO disease staging, F= (3,204) = 1.863, p=0.137, did not attain statistical significance.

Table 24.3 Two-way between –groups ANOVA for Global mean T-score, glucose and CD4 count.

Effect	**F**	**p –Value**
Main effect of glucose	0.590	0.555
Main effect of CD4	1.344	0.247
Interaction	0.409	0.665

The table above shows that the interaction effect between glucose and CD4 was not statistically significant, F (2,242) = 0.409, p=0.665. The main effect for glucose, F= (2,242) = 0.590, p= 0.555, was not statistically significant. The main effect for CD4, F= (1,242) = 1.344, p=0.247, did not attain statistical significance.

Summary of the results

In summary only with haemoglobin factor is there evidence in this study of malnutrition as a co-morbid factor having a significant effect on Neurocognitive functioning. The other three factors (variables) did not indicate a significant effect on neurocognitive funcitioning in HIV positive adults in Lusaka.

CHAPTER FIVE

5. DISCUSSION

This part of the report discusses the results that are presented in chapter four. The main aim of the study was to determine the effects of malnutrition as a co-morbid factor on neurocognitive functioning HIV positive adults in Lusaka. The findings will be presented in line with the research objectives in chapter one. The discussion will first and foremost outline a summary of the main findings. The following paragraph gives a more detailed account of the findings in chapter four.

The study consisted of both males and females. They were more females than males in the study. The participants` ages ranged from 20 to 65 years. Most of the participants were in the age of 40 year. Their levels of education ranged from 5 to 20 years.

Generally the results from the study show that malnutrition as a co-morbid factor does affect neurocognitive functioning. The effect is more noted when haemoglobin was run in the analysis. The other variables for this study did not yield a significant p - values.

5.1. Effects of malnutrition as a co-morbid factor on neurcognitive functioning in HIV positive adults.

For the purposes of the current study a case of adult malnutrition as a co-morbid factor is represented by BMI, serum protein, random blood glucose level and haemoglobin level

In order to determine the effects of malnutrition as a co-morbid factor on neurocognitive functioning, hierarchical multiple regression analysis and ANOVA were run. The analysis was run on Global T mean scores.

Results of the current study indicate that malnutrition as indicated by haemoglobin status as a co-morbid factor in HIV positive adults affects neurocoognitive functioning in adults aged between 20 and 65 years. The current findings confirm the first hypothesis. The effects usually result in low performance on neurocognitive tests. The results also

indicate that BMI, protein and glucose did not contribute significantly to the overall variance.

Additional analysis using ANOVA indicated that there was significant interaction between BMI and CD4 count as well as protein and CD4 count. However further comparison should that there was no difference in performance amongst the levels of BMI and the three level of protein. The difference was very small.

Results also indicate that haemoglobin had a significant effect on neurcognitive functioning in this sample. The results obtained are confirmed by Peter et al. (2008) who noted that there is a significant high risk of cognitive decline with low levels of haemoglobin. Peter et al. (2008) noted that haemoglobin should always be considered when evaluating individuals for any cognitive decline. Beard et al. (2004) also concurred with the results of the current study. The researchers concluded that there is a strong relationship between iron status and cognitive functioning in poor African mothers during the postpartum period. Ng et al. (2008) also considered the effect of low levels of haemoglobin in relation to cognitive and noted that low levels of haemoglobin results in reduced cognitive functioning. Morley and Lucas (1997) looked at a number of animal studies and indicated that a lot of attention should be focused on the relationship between malnutrition and brain development at various stages of human development. Even though the studies are based on animal studies, they are of great importance in establishing both principle and mechanism of any associations between nutrition and cognition. The authors seem to imply that malnutrition should be considered as the brain is developing. In terms of BMI, Ward et al. (2005) in their study also got results that were similar to the ones obtained in the current study. The researchers found that BMI did not have an effect on cognition therefore supporting the results obtained in chapter four. The conclusion was that middle aged adults may be at risk of cognitive decline in the future. Gorospe and Dave (2007) also concurred with Ward et al. (2005). The researchers concluded that increase in BMI is independently associated with increased risk of dementia in old age. It can be noted that even though the effects of elevated BMI on global cognition are not evident in the current study, its effects might be more

prominent in the future because participants with elevated BMI are at risk of cognitive decline in old age. The findings of the study should not be disregarded.

In terms of protein, Liewellyn et al. (2010) and Ng et al. (200) found results that are contrary to the ones obtained in the study. Liewellyn et al. (2010) demonstrated the importance of adequate levels of nutrients on cognitive functioning. The researchers concluded that serum albumin plays a vital role in the binding of drugs, hormones, iron and free fatty acids, and reduced levels of serum albumin may contribute to cognitive impairment. Ng et al. (2008) also found that low levels of albumin are associated with low cognitive performance. The researchers also considered the effects of Body Mass Index (BMI) in relation to cognition. And they found similar effects in relation to cognitive functioning.

5.2 Effects of malnutrition as a co-morbid factor on neurocogntive test domains.

In order to identify which neurocognitive domains are most affected by malnutrition as a co-morbid factor in HIV positive adults in Lusaka, MANOVA was used. The analysis was run on individual tests that represent the dependent variable (which is in this case neurocogntive test performance).

Results of the current study show the effects of BMI were associated learning, glucose was associated with verbal fluency and haemoglobin was associated with executive functioning, recall and learning. The results indicated that the effects of protein were not observed on any of the seven cognitive domains namely executive functioning, recall, learning, SIP, motor, verbal fluency and working memory. Results obtained from this study are similar to Laus et al. (2011) `s study results. Laus et al. (2011) found that malnutrition tends to affect the hippocampus and studies have shown that this part of the brain is important for learning and memory. So in this regard changes to hippocampal functioning may result in deficits in learning and memory. The results of the study are confirmed by these researchers in the sense that effects of malnutrition are more prominent on the two cognitive domains that is learning and recall.

West and Haan (2009) noted that overall obesity would be a protective factor when it comes to cognitive decline. This may reflect age-related changes in body composition and the association of visceral fat with metabolic dysregulation. The study confirms the results obtained when MANOVA and ANOVA were run. The results showed that participants with high levels of BMI performed better on tests of learning than participants with normal levels of BMI. The difference in means between the two groups was statistically significant. This simply means that high levels of BMI would act as protective factors when it comes to cognitive decline for this age group.

Contrary to these findings Hoorweg and Stanfield (2008) in their study found that anthropometry, intellectual and motor abilities are affected by chronic undernutrition in children. The study also found that generally intellectual abilities, reasoning and spatial abilities were most affected by protein energy malnutrition. Memory and rote learning were intermediately affected and finally language was least affected by protein energy malnutrition. Cournot et al. (2006) concluded that high BMI was associated with cognitive decline at follow – up. The decline was observed on the tests of SIP as well as learning in middle aged men and women. Sabia et al (2009) also found results that are contrary to the results obtained in chapter four. They found that a large increase in BMI from early to late midlife was associated with lower executive function. The conclusion from their study was that obesity, underweight in adulthood is associated with lower cognitive scores in late midlife. Hassing et al. 2010 also concluded that there is a relationship between midlife overweight and lower cognitive performance in old age.

Kaplan et al. (2001) also found that pure protein, carbohydrate and fat improve performance on memory 15 minutes after ingestion in the elderly population. In this study they also found that contrary to popular hypothesis high levels of blood protein did not improve memory. Their conclusion is similar to the results obtained in chapter four. The results are that glucose did not have an effect on memory.

White and Wolraich (1995) found results that were contrary to the one obtained from the current study. White and Wolraich (1995) found that glucose plays an importance role in potentiating memory processes; this distinction has been observed in both rats and in human beings

The researchers` conclusions differ from the results obtained for a number of reasons. One of the reasons would be that most of them were conducted on children. Children`s brains are still developing therefore the effects of malnutrition are more evident in this group as a compared to adults between the ages of 20 and 65 years. The other reason would be some of the studies were longitudinal studies. For such it is very easy to determine changes to brain function in terms of malnutrition and cognition. In a cross sectional study it is difficult to note the any changes to brain function especially if there are just beginning. Most of the researchers concluded that overweight middle aged adults are at risk of developing a number of cognitive deficits in their old age. So the factor of malnutrition as measured by protein, BMI and glucose may not be observed at this particular time but they have future repercussions on the functioning of the brain.

5.3. Gender and nutritional status on neurocognitive functioning

In order to identify whether both gender and nutritional status have an effect on neurocognitive functioning in HIV positive adults in Lusaka province, MANOVA was used. The analysis was run on the variables of nutritional status as well as gender on global mean T scores.

The second hypothesis stated that both gender and nutritional status will improve neurocognitive functioning in HIV positive adults in Lusaka. The results obtained have not confirmed this hypothesis.

The results obtained indicate that all there is no effect of both gender and nutritional status on neurocognitive functioning in HIV positive adults. The results indicate that the interaction between gender and BMI, gender and protein, gender and glucose and gender and haemoglobin did not indicate a significant effect when global mean T scores and deficit scores were used.

Castel, Shahar and Harman-Boehm (2006) in evaluating gender difference in nutritional risk of older people in Israel, found results that are contrary to the findings above. Their results showed that more females than males were at risk of under-nutrition. The population at nutritional risk had a higher risk of rate of depression, lower cognitive and physical ability. Nutritional risk for men was associated with higher levels of depression,

longer stay in the hospital and poor appetite. The results from this study show that females were at risk of under-nutrition as compared to males.

Gur et al (1999) looked at the sex differences in brain gray and white matter in young adults and the correction between brain gray matter and white matter with cognitive performance. The researcher discovered that they are differences in brain gray matter and white matter in males and females and conducted that these difference contribute significantly to difference in cognitive performance between males and females.

Hamid et al. (2011) found results that differed from the results found in this study in terms of the effects of gender and nutritional status on academic performance and cognitive. They found that found girls performed better on academic skills than the boys. In cognitive functioning the boys performed better than the girls even though the results were not significant. They also found that nutritional status was linked to better academic performance in these children. Another study by Widenhorn-Müller, Hille, Klenk and Weiland (2008) found also the interaction of gender and nutritional status on cognition. The only difference was that in their study, the males performed better than the females in terms of cognition.
Hestad et al. (2012) also noted that gender has an effect on neurocognitive test performance. From their results males performed better than females.

Although the results obtained in the study indicate that malnutrition as a co-morbid, as assessed by a number of variables such as protein, glucose and BMI have no effect on global cognitive functioning, the message of nutrition should not be neglected. It is important to rectify the situation right now by insuring that malnourished participants are taken care of. Restoration of normal levels of protein, glucose and BMI is vital.

CHAPTER SIX

6. LIMITATION OF THE STUDY, CONCLUSION AND RECOMMENDATIONS

6.1. Limitations of the study

There are a number of limitations that were faced during the course of the research but only the major ones will be highlighted.

1. The major limitation of the study was financial constraints which made it very hard to get the participants` lipid profile. It will have been interesting to look at triglycerides in this sample and try to see if there is an effect of lipids on cognitive functioning in HIV positive adults. The participants would also have had an opportunity to know more about their lipid profile.

2. Lack of data from other parts of Zambia especially rural areas of Zambia. The data was collected from urban areas of Lusaka. It would have been very helpful to also analyze data from rural areas of Zambia for the purposes of generalization the results. Storage units were needed for storing blood for laboratory analysis and most rural areas lack proper storage units in rural health centres.

3. The study had a number of additional questionnaires that had to be administered. So for some participants the whole process took more than three hours to complete especially during the first week of data collection and with participants with low levels of education.

4. The sample had to be reduced to 263 due to data that was lost from WCST and category tests. For the purposes of analysis the sample size had to be reduced.

6.2. Conclusion

Results obtained in the study seem to suggest that there is generally an effect of malnutrition as a co-morbid factor on neurocognitive functioning in HIV positive adults in Lusaka particularly in low haemoglobin states. Malnutrition as a co-morbid factor did not seem to have an effect on global cognitive functioning when measures of BMI, protein and glucose were used to assess this variable.

On closer analysis of each neurocognitive domain, the effect of malnutrition as a co-morbid factor was observed mainly when hemoglobin, glucose and BMI were used to assess this effect. This effect was observed on a number of domains namely verbal fluency, learning, executive functioning and recall. Low or high states of protein did not have an effect on any of the seven neurocognitive domains, out of the four variables used to determine malnutrition in the current study.

Just because these measures of malnutrition as a co-morbid factor, BMI, protein and glucose do not seem to have such a strong effect on neurocognitive functioning, the message of proper nutrition should not be disregarded. It is important to ensure that patients maintain normal levels of BMI, protein and glucose if repercussions are to be avoided.

6.3. Recommendations

This study is the first in its kind to be carried out in Lusaka; it would be more helpful if the study was replicated in other parts of Zambia especially in rural areas. Replication of the study would be helpful in generalising these results to all citizens of Zambia. Studies like this in other parts of the country would help in determining which part of the population is more affected by cognitive decline as a result of malnutrition.

Since the results show that BMI, protein and glucose have no effect on general cognitive functioning, it can be assumed that the effects of malnutrition as a co-morbid factor could be recognized better in a longitudinal study.

It would also be more helpful if the future study included a lipid profile. It would help shedding more light on the relationship between lipid and neurocognitive functioning in HIV positive adults.

REFERENCES

Annunziata, P. (2003) Blood-brain barrier changes during invasion of the central nervous system by HIV-1: old and new insights into the mechanism. *Journal of Neurology,* 250 (8), 901–906.

Asenso- Okyere, K., Aragon, C., Thangata, P., Andam, K. & Mekonnen, D.A. (2010) HIV and AIDS and farm labor productivity: A review of recent evidence in Africa. *Journal of Development and Agricultural Economics,* 2(12), 406 – 415.

Beard, J. L., Hendricks, M. K., Perez, E. M., Murray – Kolb, L. E., Berg A., Vernon – Feagans, L., Irlam, J., Isaacs, W., Slve, A. & Tomlinson, M. (2005) Maternal iron deficiency anaemia affects postpartum emotions and cognition. *Journal of Nutrition, 135, 267 – 272.*

Caste,l H. & Shahar, D., Harman-Boehm, I. (2006). Gender Differences in Factors Associated with Nutritional Status of Older Medical Patients. *Journal of the American College of Nutrition,* 25 (2), 128–134

Cournot, M., Marquie,´ J. C., Ansiau, D., Martinaud, C., Fonds, H., Ferrie`res, F. & Ruidavets, J. B. (2006). Relation between body mass index and cognitive function in healthy middle-aged men and women. *Neurology,* 67, 1208.

Cysique, L. A., Letendre, S. L., Ake, C., Jina, H., Franklin, D. R., Gupta, S., Shi, C., Yu, X., Wu, Z., Abramson, I.S., Granta, I., Heaton, R.K. & the HIV Neurobehavioural Research Center group.(2009). Incidence and nature of cognitive decline over 1 year among HIV-infected former plasma donors in China. *AIDS,* 23, 000–000.

Gorospe, E.C. & Dave, K. J. (2007). The risk of dementia with increased body mass index. *Age and Ageing,* 36, 23–29.

Gupta, S., Vaida F., Riggs, K, Jin, H., Grant, I., Cysique, L., Shi, C., Yu, X., Wu, Z., Heaton, R. K. & the HIV Neurobehavioral Research Center (HNRC) Group. (2011).

Neuropsychological Performance in Mainland China: The Effect of Urban/Rural Residence and Self-Reported Daily Academic Skill Use. *Journal of the International Neuropsychological Society,* 17, 163–173.

Gur, R. I., Turetsky, B. I., Matsui, M., Yan, M., Bilker, W., Hughett, P. & Gur, R. E. (1999). Sex Differences in Brain Gray and White Matter in Healthy Young Adults: Correlations with Cognitive Performance. *Journal of Neuroscience, 19*(10), 4065–4072

Hamid, J. J. M., Mitra'z, A. K., Hasmiza, H., Pim, C. D., Ng, L. O. & Manan, W. W. M. (2002). Effect of Gender and Nutritional Status on Academic Achievement and Cognitive Function among Primary School Children in a Rural District in Malaysia. *Malaysian Journal of Nutrition,* 17(2), 8.

Hassing, L. B., Dahl, A. K., Pedersen, N. L & Johansson, B. (2010). Overweight in Midlife Is Related to Lower Cognitive Function 30 Years Later: A Prospective Study with Longitudinal Assessments. *Dementia Geriatric Cognitive Disorders,* 29, 543–552

Heaton, R. K., Grant, I., Butters, N., White, D. A., Kirson, D., Atkinson, J. H., McCutchan, J. A, Taylor, M. J., Kelly, M. D., Ellis, R. J., Wolfson T., Velin R., Marcotte, T. M., Hesselink, J. R., Jernigan, T. L., Chandler, J., Wallace, M., Abramson, I., & THE HNRC GROUP. (1995). The HNRC 500-Neuropsychology of HIV infection at different disease stages. *Journal of International Neuropsychological Society,* 1: 231-251.

Hestad, K.N., Menon, A.J., Silalukey-Ngoma, M., Franklin, D.R., Imasiku, L.M., Kalima, K. & Heaton, R.K. (2012). Sex Differences in Neuropsychological Performance as an Effect of Human Immunodeficiency Virus Infection. A Pilot Study in Zambia, Africa. *Journal of Nervous and Mental Disorders,* 200 (4), 336- 342.

Holguin, A., Banda, M., Willen, E. J., Malama, C., Chiyenu, K. O., Mudenda, V. C. & Woods, C. (2011). HIV - Effects on Neuropsychological Performance in a Resource-Limited Country, Zambia. *AIDS and Behaviour,* 15(8) 1895-1901.

Hoorwig, J. & Stanfield, J. P. (2008). The effects of Protein Energy Malnutrition in Early Childhood on Intellectual and Motor abilities in Later Childhood and Adolescence. *Development Medicine,* 18(3) 350 – 380.

Kalanda, B., Mamimine, P., Taela, K., Chingandu, L. & Musuka, G. (2010). Implementation of regional and international HIV and AIDS prevention, treatment, care and support conventions and declarations in Lesotho, Malawi and Mozambique. *Educational Research and Review,* 5 (9), 465-470.

Kallings, L. O. The first postmodern pandemic: 25 years of HIV/AIDS. (2008) *Journal of Internal Medicine,* 263 (3), 218-243.

Kaplan, J. R., Greenwood, E.C., Winocur, G. & Wolever, M.S.T. (2001). Dietary protein, carbohydrate, and fat enhance memory performance in the healthy elderly. *American Journal of Clinical Nutrition,* 74, 687–93.

Knox, T. A., Zafonte – Saunders, M., Fields – Gardner, C., Moen, K., Johansen, D. & Paton, N. (2003). Assessment of Nutritional Status, Body Composition, Human Immunodeficiency Virus – Associated Morphologic Changes. *Clinical Infectious Disease,* 36 (suppl 2), S63 – 8.

Laus, M. F., Vales, F. M. D. L., Costa, M. B. T. & Almeida, S. S. (2011). Early Postnatal Protein-Calorie Malnutrition and Cognition: A Review of Human and Animal Studies. *International Journal of Environmental Research and Public Health, 8*, 590-612

Lezak, M. D., Howieson, D. B & Loring, D. W. (2004). Neuropsychological Assessment (4th Ed.). New York, NY: Oxford University Press.

Liewellyn, D. J., Langa, K.M., Robert, P. Friedland, P. R. & Lang, I. A. (2010). Serum albumin concentration and cognitive impairment. *Current Alzheimer Research,* 1, 91- 96

Mahan, L. K. & Escott – Stump, S. (2008). Krause`s Food and Nutrition Therapy. St Louis. Saunders Elsevier.

Mattson, M. P., Haughey, N. J. & Nath, A. (2005) Cell death in HIV dementia. *Cell Death and Differentiation,* 12 (1): 893–904.

Mclaren, D. S. (1981) Nutrition and disorders. (3rd Edi) New York. Churchill Livingstone.

Morley, R. & Lucas, A. (1997) Nutrition and cognitive development. *British Medical Bulletin,* 53(1), 124- 134.

Ndekha, M. J., Manary, M. J., Ashorn, P. & Briend, A. (2005). Home-based therapy with ready-to-use therapeutic food is of benefit to malnourished, HIV-infected Malawian children. *Acta Pædiatrica,* 94, 222–225.

Nerad, J., Romeyn, M., Silverman, E., Allen- Reid, J., Dieterich, D., Merchant, J., Pelletier, A.V., Tinnerello, D. & Fenton, M. (2003). General Nutrition Management in Patients Infected with Human Immunodefciency Virus. *Clinical Infectious Diseases,* 36(Suppl): S52-62

Ng, T., Feng, L., Niti, M. & Yap, K.B. (2008). Albumin, haemoglobin, BMI and cognitive performance in older adults. *Age and Ageing,* 37, 423- 429.

Njamnshi, A. K., Djientcheu, V. P., Fonsah, J. Y., Yepnjio, F.N., Njamnshi, D. M. & Muna, W.F. (2008). The international HIV Dementia Scale is a useful tool for screening for HIV – associated dementia in HIV infected adults in Yaounde Cameroon. *Acquired Immune Deficiency Syndrome,* 49 (4), 393- 397.

Obi, S. N., Ifebunandu, N. A. & Onyebuchi, A. K. (2010). Nutritional status of HIV-positive individuals on free HAART treatment in a developing nation. *Journal of Infections in Developing Countries,* 4(11), 745-749.

Onyango, A. C., Walingo, M. K., Mbagaya, G. & Kakai, R. (2011). Body Composition and CD4 Cell Count of HIV Sero- positive Adults Attending Out – patients1`s clinic in Chulaimbo Sub – district Hospital Kenya. *Pakistan Journal of nutrition,* 10 (6), 582 – 588.

Opara, D.C., Umoh, I. B. & John, M. (2007). Effects of nutritional counseling and micronutrient supplementation on biochemical parametres of persons living with HIV and ADIS in Uyo Nigeria. *Pakistan Journal of nutrition,* 6 (3), 220- 227.

Pagana, D. K & Pagana, T. J. (2002). Moby`s Manual of Diagnotic and Laboratory test. (2nd Edi) St Louis. Mosby.

Peters, R., Burch, L., Warner, J., Beckett, N., Poulter, R. & Bulpitt, C. (2008). Haemoglobin, anaemia, dementia and cognitive decline in the elderly, a systematic review. *BMC geriatrics,* 8, 18.

Rawat, R., Kadiyala, S. & McNamara, E. P. (2010). The impact of food assistance on weight gain and disease progression among HIV-infected individuals accessing AIDS care and treatment services in Uganda. *BMC Public Health,* 10, 316- 324.

Report on the global Epidemic 2006. A UNAIDS 10th anniversary special edition. Joint United Nations programme on HIV and AIDS

Robertson, K., Liner, J. & Heaton, R. (2009). Neuropsychological Assessment of HIV-Infected Populations in International Settings. *Neuropsychology Review,* 19, 232–249

Robertson, R. K., Nakasujja, N., Wong, M., Musisi, S., Katabira, E., Parsons, T. D., Ronald, A. & Sacktor, N. (2007). Pattern of neuropsychological performance among HIV positive patients in Uganda. *BMC Neurology,* **7**(8), 1471.

Sabia, S., Kivimaki, M., Shipley, M. J., Marmot, G. M. & Singh-Manoux, A. (2009). Body mass index over the adult life course and cognition in late midlife: the Whitehall II Cohort Study. *Amercian Journal of Clinical Nutrition,* 89, 601–607.

Saddock, B. J. & Saddock, V. A. (2007). Kaplan & Saddock`s Synopsis of Psychiatry. (10^{th}Edi). Philadelphia. Lippincott Wilkins.

Sembe, D., Smyth, R., Burns, J., Darjee, R. & Mclntosh, A. (2005). Oxford Handbook of Psychiatry. Oxford. Oxford University Press.

Singh, D., Joska, J. A., Goodkin, K., Lopez, E., Myer, L., Paul, H. R. & John, S. (2010). Normative Scores for a Brief Neuropsychological Battery for the Detection of HIV – associated Neurocognitive Disorder (HAND) among South Africans. *BMC Research Notes,* 3: 28.

Stemler, S. E., Chamvu, F.C. & Chart, H. (2008). Assessing competencies in reading and mathematical in Zambian children. In Grigorenko E. (edition), Multicultural Psychoeducational Assessment (pp. 157 – 184). New York: Springer Publishing Company

Strauss, E., Sherman, E. M .S. & Spreen, O. (2006). A Compendium of Neuropsychological Tests. (3^{rd} Edition). New York: Oxford University Press.

Sztam, K. A. (2010). HIV and Nutrition. St Louis. Mosby.

Ward, M. A., Carlsson, C. M., Trivedi, M. A., Sager, M. A. & Johnson, S. C. (2005). The effect of body mass index on global brain volume in middle-aged adults: a cross sectional study. *BMC Neurology,* 5, 23

White, J. W. & Wolraich, M. (1995). Effects of Sugar on behaviour and mental performance. *American Journal of Clinical Nutrition,* 62 (Suppl), 242S- 95

Widenhorn-Müller, K., Hille, K., Klenk, J. & Weiland, U. (2008). Influence of Having Breakfast on Cognitive Performance and Mood in 13 to 20 Year-Old High School Students: Results of a Crossover Trial. *Pediatrics,* 122 – 279.

Williams, S. R. (1997). Nutrition and Diet Therapy. (8th Edi). St Louis. Mosby.

Williams, S. R. (1995). Nutrition and Diet Therapy. (10th Edi). St Louis. Mosby

Woods, S. P., Moore, D. J., Weber, E. & Grant, I. (2009). Cognitive Neuropsychology of HIV-Associated Neurocognitive Disorders. *Neuropsychology Review* 19: 152-168.

Zambia Demographic Health Survey 2007. Implemented by the Central Statistical Office (CSO) Ministry of Health. Tropical Diseases Research Centre, University of Zambia & Macro International Inc 2009.