Impacts of HIV Subtype on Occurrence of the HIV - Dementia among the HIV Patients who are on HIV-1 Antiretroviral therapy in Dar es salaam and Njombe region, Tanzania.

Authors names
:[1,2,3*], Kigumi Hamimu Omary, [4,5] Mmbaga Blandina Theophil, [6]Nyanda Elias Ntinginya, [6]Olomi Willyhelmina, [1]Vianney John-Mary

Authors affiliation:
[1]Department of Health and Biomedical Sciences, School of Life Sciences and Biomedical Engineering, The Nelson Mandela African Institution of Sciences and Technology, Arusha, Tanzania
[2]Department of the health services, Local Government Training Institute, Dodoma, Tanzania
[3]Department of Prevention Services, National Tuberculosis and Leprosy Program, Ministry of Health, Dodoma, Tanzania
[4]Kilimanjaro Clinical Research Institute, Kilimanjaro Christian Medical Centre, Moshi, Tanzania
[5] Kilimanjaro Christian Medical University College, Moshi, Tanzania
[6]National Institute for Medical Research, Mbeya Medical Research Centre

Abstracts : HIV/AIDS -dementia is a common complex condition that occurs to the patients infected with Human immunodeficiency virus (HIV) with CD4 less than 200 cell/ml. HIV-Dementia occurs when the HIV virus spreads to the brain and Central nerve system. Antiretroviral therapy (ART) can reduce the occurrence HIV dementia if timely initiated and properly used during the course of the treatment. We aimed to determine the relationship between Dementia and HIV subtype in people leaving with HIV (PLHIV) on HIV-1 ART. A hospital based retrospective cross-sectional study conducted in Njombe and Dar es salaam region in Tanzania. HIV-seropositive (HIV+) individuals who were on HIV -1 ART regimen from 2016 to 2021 were recruited in the study. Questionnaire and WHO AIDS-Dementia Assessment tool (2012) and The International HIV-Dementia Scale were used to assess the presence of dementia among the HIV patients on ART. All data gathered were entered in the SPSS version 26.0 for analysis and interpretation. Frequencies and Percentage was used to interpret data. Univariate Logistic regression and Chi-square were used to find the association of the occurrence of HIV dementia. A total of 300 PLHIV were recruited in the study, whereas, 140 (46.7%) were male and 160 (53.3%) female. The mean age of the participants was 35 (± 0.24) years and ranged from 15–90 years old. Overall, 132(44.0%) of the participants had dementia. The higher prevalence of dementia were observed in 59.2% participants with HIV-1/HIV-2 (PLHIV-1+2), 54.6% with HIV-2 (PLHIV-2) and 38.2% for participants with HIV-1 (PLHIV-1) infection . After adjusting age, sex, level of education, marital status, monthly income, occupation, baseline CD4, weight and baseline viral load; PLHIV-2 had 1.81 fold increased risk of dementia (RR 1.81, 95% CI 1.33 to 2.36) and PLHIV-1+2 had 1.71 fold high risk of dementia compared with PLHIV-1 infected (RR 1.71, 95% CI 1.27 to 2.29) compared with HIV-1 patients. Age, sex, level of education, marital status, monthly income and occupation were observed as perpetuating factors for occurrence of the HIV dementia. The study documented high risks of occurrence of the HIV dementia among the PLHIV-2 and PLHIV-1+2 participants Also the study observed age, sex , economic status and marital status as perpetuating for occurrence of HIV dementia. Therefore, the study recommend the use of the proper ART regimen for HIV-2 and HIV 1+2 dual infection to reduce the occurrence of the HIV-dementia among the HIV patients.

Index Terms: HIV-1, HIV-2, HIV 1+2 dual Infections, Dementia, Antiretroviral therapy

1.0.INTRODUCTION

Since 1981 HIV infection and AIDS have been known as global public health concern that causes high morbidity and mortality, HIV-1 and HIV-2 is the only types known. WHO estimate out of the 40 million living with HIV, more than 2 million PLHIV living with HIV- 2 [1],Despite of the decrease of the general HIV prevalence among the adult population from 40 million in 2018 [1] to 37.5 million in 2022 [2]   the situation is still worse to Sub Saharan (SSA)countries include ing Tanzania. According to WHO there are

slow decreasing of the new HIV infection whereby there are 24.3 M of the adult population living with HIV in 2022 compared to 26.7 M of that of 2018 [1]. Globally the AIDS related mortality fallen from 52% in 2018 to 47.0% in for 2021. [1.2]. Tanzania like other SSA countries have 1.4 M PLHIV in 2021 compared to 1.7 M of 2018. The prevalence among the adult population was reduced from 4.7% to 4.5 % and deaths of AIDS related cases were 18,348 [3,4]

Dementia is a syndrome that can be caused by a number of diseases which over time destroy nerve cells and damage the brain, typically leading to deterioration in cognitive function, According to WHO Dementia i seventh leading cause of death and one of the major causes of disability and dependency among older people globally. currently more than 55 million people have dementia worldwide, over 60% of whom live in low- and middle-income countries. Every year, there are nearly 10 million new cases. [5,6] .HIV/AIDS -dementia is a common complex condition that occurs to the patients infected with HIV. HIV-Dementia occurs when the HIV virus spreads to the brain. Symptoms of HIV-dementia include loss of memory, difficulty thinking, concentrating, and or speaking clearly, lack of interest in activities and gradual loss of motor skills. The studies shown HIV dementia commonly occurs when PLHIV CD4+ count falls to less than 200 cells/microliter that resulted to the increase of the viral loads that attacks the central nervous system and brain [5]., HIV dementia was observed to occur among the PLHIV in there course of the treatment [6, 7]. Globally HIV dementia explain as the among associated condition that reduced the life expectancy of the HIV patients Significantly incidence HIV dementia to the PLHIV resulted to either deaths or dis abilities if not well managed.[7,8]

Ant Retro therapy is the corner stone for reducing the risks of the occurrence of the HIV dementia among the HIV patients due to its ability of the increase of the CD4 cells and reducing the viral load that reduce. Current studies shown the prevalence of HIV dementia 7 to 27% for the patient who are on ART treatment and 30 to 40% for those who are not started use the ART[9] Tanzania like other countries faced the problem of the increase of the HIV patients with HIV Despite of the use of the ART for treatment of the HIV patients and manage the occurrence of the HIV/AIDS related medical conditions, there is reporting increase of the prevalence of the HIV dementia from 33.3% to 36% [10].This study aimed to assess the impact of HIV subtype on occurrence of the HIV dementia among the PLHIV who are on HIV-1 ART regimen in Njombe and Dar es salaam region, Tanzania.

2.0.NEED OF THE STUDY.

Dementia is the medical condition brought on by a variety of diseases that destruct the function of the brain and kill nerve cells, which usually results in a decline in cognitive ability. HIV/AIDS -dementia is a common complex condition that occurs when HIV virus penetrates the brain. HIV-related dementia symptoms include memory loss, trouble focusing, thinking, and/or speaking effectively, as well as a lack of interest in in activities and gradual loss of motor skills.. The studies shown HIV dementia commonly occurs when PLHIV CD4+ count falls to less than 200 cells/microliter that resulted to the increase of the viral loads that attacks the central nervous system and brain. Significantly incidence HIV dementia to the PLHIV resulted to either deaths or dis abilities if not well managed. Recent studies shown the global prevalence of HIV dementia range between 7–27%. Like other countries , Tanzania has prevalence of 36.0% . Despite of having the HIV-1 and HIV-2 types in Tanzania the use of the HIV-1 ART regimen is the cornerstone for treatment of the HIV and reduction of the occurrence of the HIV dementia among the HIV patients. . The study's results provide information on the Impacts of these HIV Subtype on Occurrence of the HIV - Dementia among the HIV Patients who are on HIV-1 Antiretroviral therapy in Dar es salaam and Njombe region, Tanzania. Also, the results will help the health policymakers to plan for initiation of the HIV-2 ART regimen for treatment of the hiv-2 and HIV 1+2 infections for purpose of improvement of occurrence of the HIV-dementia,

3.0. RESEARCH METHODOLOGY
3.1. Study area
The study was conducted in eight health facilities with HIV center and treatment centers found in Njombe and Dar es salaam . Njombe region with population of 889,946 [11] was selected due to its highest prevalence of HIV in Tanzania 11.4% [3] and existing social cultures such as polygamy and international business interactions on the Southern part of the country. The presence of large plantation and passing with southern highland road that used heavy traffic cars from the Dar es salaam port to the southern countries attract migrant and foreigners from the nearest countries thus the probability of obtaining HIV-2 infections was expected to be high. Dar es salaam with estimated population of 7,405,000 [11] and prevalence of 6.2% [3] was selected due to its

nature of activities as the commercial city that attracts more foreigners and migrants, business interactions and high population thus the probability of HIV-2 infections existence was also expected to be high.

3.2 Population and Sample

Using a precision formulae of calculating sample size, A total of 300 study Participants were recruited from treatment patients files from the eight selected HIV care and treatment sites. Each region contributed to 150 study participants that were selected by the division of the total participants in the ration of the 1:1 looking at the number of patients at the site and the total samples size. Based on the fact that the regimen which are existing in Tanzania is for HIV-1 treatment, hence, enrolment was based on those who are on HIV-1 ART regimen treatment from 2016 to the 2022 and undergone four immunological (CD4 count) tests and virological (VRL) tests. Those who aged below 18 and above 55 and pregnant mothers who are on preventive of mother to child treatment program (PMTCT) was exclude. A multi-stage sampling was done whereby purposive sampling was used to select regions as explained, then Districts and facilities of the study were selected. Simple randomly sampling were used to select the study participants.
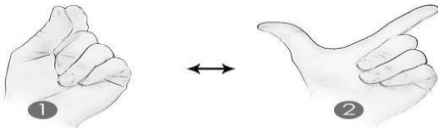
3.3. Data collection tools and methods

Structured administered questionnaire were used to gather information on social demographic of the Participants. Assessment and screening of the HIV patients among the participants was dome using HIV dementia was screened using the combined WHO AIDS-Dementia Assessment tool (2012) [12] and The International HIV-Dementia Scale; A new rapid screening test for HIV dementia (2015) [13]. As per tools, HIV dementia assessment includes the measure of the Memory registration, Motor speed, psychomotor speed and memory recall, whereby, each category was scored 1- 4 marks and controlled for 1 minutes using the stop watch. The PLHIV was asked to do explained actions per each category for one minute whereby the number of repeated actions done by the PLHIV for one minute and scored. The sum of the score for each category used to conclude the existence of the HIV dementia for PLHIV. Out of 16 marks, if the score marks was less than ten it was indicating the participants to has dementia

Figure 1: WHO HIV dementia Assessment tool

Memory registration assessment

Explanation	Scores
☐ Give four words to recall (**dog, hat, bean, red**) -1minute to say each. ☐ Then ask the patient all four words after you have said them ☐ Repeat words if the patient does not recall them all immediately. ☐ Tell the patient you will ask for recall of the words again a bilateral ☐ Mark the patient according to his/her recall ability	4 word =4 3 word =3 2 word =2 1 word =1 Unable =0

Motor speed assessment

Explanation	Scores
☐ Have the patient tap the first two fingers of the non- dominant hand as widely and as quickly as possible ☐ Tell the patients to repeat action quickly and count the number of action for 5Second ☐ Mark the patient according to the number of actions done 	☐ 4 word =4 ☐ 3 word =3 ☐ 2 word =2 ☐ 1 word =1 ☐ Unable =0

Psychomotor speed Assessment

Explanation	Scores
Have the patient perform the following sequence of movements with the non-dominant hand as quickly as possible: 　☐　Clench hand in fist on flat surface 　☐　Put hand flat on surface with palm down 　☐　Put hand perpendicular to flat surface on the side of the 5thdigit 　☐　Demonstrate and have patient perform twice for practice.	4 word =4 3 word =3 2 word =2 1 word =1 Unable =0

Memory recall assessment

Explanation	Scores
Ask the patient to recall the four words and one point for each word able to recall (**dog, hat, bean, red**) *1. For words not recalled, prompt with a semantic clue and mark him/her 0.5 if is right:* 　•　**DOG, -ANIMAL?** 　•　**HAT-PIECE OF CLOTHES?** 　•　**BEAN-VEGETABLE?** 　•　**RED- COLOR**	3word =4 3 word =3 2 word =2 1 word =1 Unable =0

Source: WHO AIDS-Dementia Assessment tool (2012)

3.4. Data analysis, interpretation and Management

The data obtained was entered in the SPSS version 26.0 for cleaning and analysis. The frequency and percentage were used to interpret the magnitude of the occurrence of the dementia among the PLHIV and compared within HIV subtypes. The assessment of the risk factors for occurrence of the HIV dementia among the HIV subtypes were assessed using univariate logistic regression analyses with $p \leq 0.005$. The OR and their 95% confidence interval (CI) was used to identify the association of the occurrence of the HIV dementia with social demographic of the participants.

4.0. RESULTS AND DISCUSSION
4. 0. RESULTS
3.1. Social Demographic of the Participants

A total of 300 PLHIV were recruited in the study, whereas,140 (46.7%) were male and 160 (53.3%) were female. Among the recruited PLHIV, 207 had HIV-1, 44 had HIV-2, and 49 had HIV-1+2 dual infected. The mean age of the patients was 35 years (ranging from 15–90 years old) with standard deviation of ± 0.24. The more affected age group was 41-55 years for PLHIV-1 which was 83 (40.1%) and for PLHIV-2 and PLHIV 1+2 dual infection the age group 26-40 with
16(36.4%) and 19(38.8%) each were more infected, respectively. According to HIV types female participants were more dominant in both HIV-1 110 (53,6%), HIV-2 and HIV 1+2 dual infection 25 (50.6%) each, respectively. For education level with HIV-1 117(56.5), HIV-2 (20(45.5) and HIV 1+2 dual infection 26(53.1%) had primary education. Also the results showed PLHIV-1 were married 68(32.9%), while PLHIV-2 and PLHIV 1+2 dual infections most were single 18 (40.9%) and 19(38.9), respectively. Also according to economic status both HIV-1 116(56.0%), HIV-2 25(55.5%) and HIV 1+2 dual infection 168 (55.1%) has income of < 10,000Tzsh per months. Table 1 below summarizes the demographic characteristics based on HIV types.

Table 1. Social Demographic Characteristics of

Variables	HIV-1 N (%)	HIV-2 N (%)	HIV1/2 N (%)	Total n (%)
Age				
11-25 yrs	43 (20.8)	12 (27.3)	10 (20.4)	65 (21.7)
26-40 yrs	62 (30.0)	16 (36.4)	19 (38.8)	97 (32.3)
41-55 yrs	83 (40.1)	14 (31.8)	17 (34.7)	114 (38.0)
>55 yrs	19 (9.2)	2 (4.6)	3 (6.1)	24 (8.0)
Sex				
Male	97 (46.9)	19 (43.2)	24(49.0)	140 (46.7)
Female	110 (53.1)	25 (56.8)	25 (51.0)	160 (53.3)
Education level				
None	19 (9.2)	2 (4.6)	6 (12.2)	27 (9.0)
Primary	117 (56.5)	20 (45.5)	26 (53.1)	163 (54.3)
Secondary	61 (29.5)	19 (43.2)	15 (30.6)	95 (31.7)
College	10 (4.8)	3 (6.8)	2 (4.1)	15 (5.0)
Marital status				
Single	61 (29.5)	18 (40.9)	19 (38.8)	98 (32.7)
Married	68 (32.9)	8 (18.2)	16 (32.7)	92 (30.7)
Widow	29 (14.0)	7 (15.9)	6 (12.2)	42 (14.0)
Cohabited	5 (2.4)	1 (2.3)	0 (0)	6 (2.0)
Divorced	44 (21.3)	10 (22.7)	8 (16.3)	62 (20.7)
Income				
< 10,000	116 (56.0)	25 (56.8)	27 (55.1)	168 (56.0)
10,000-100,000	49 (23.7)	10 (22.7)	13 (26.5)	72 (24.0)
100000-500000	34 (16.4)	9 (20.5)	7 (14.3)	50 (16.7)
>500000	8 (3.9)	0 (0)	2 (4.10)	10 (3.3)
Occupation				
Employed	36 (17.4)	7 (15.9)	9 (18.4)	52 (17.3)
Self employed	123 (59.4)	21 (47.7)	26 (53.1)	170 (56.7)
Unemployed	48 (23.2)	16 (36.4)	14 (28.6)	78 (26.0)

3.2. Trends of occurrence HIV dementia among the PLHIV by HIV subtypes

Overall, 132(44.0%) of the patients had dementia: The proportional of dementia varied significantly between HIV subtypes (p=0.009), with higher prevalence 59.2% among patient with PLHIV1/2, 54.6% among PLHIV-2 and 38.2% among PLHIV-1 infection.

Figure *1: Trends of occurrence HIV dementia among PLHIV by HIV subtypes*
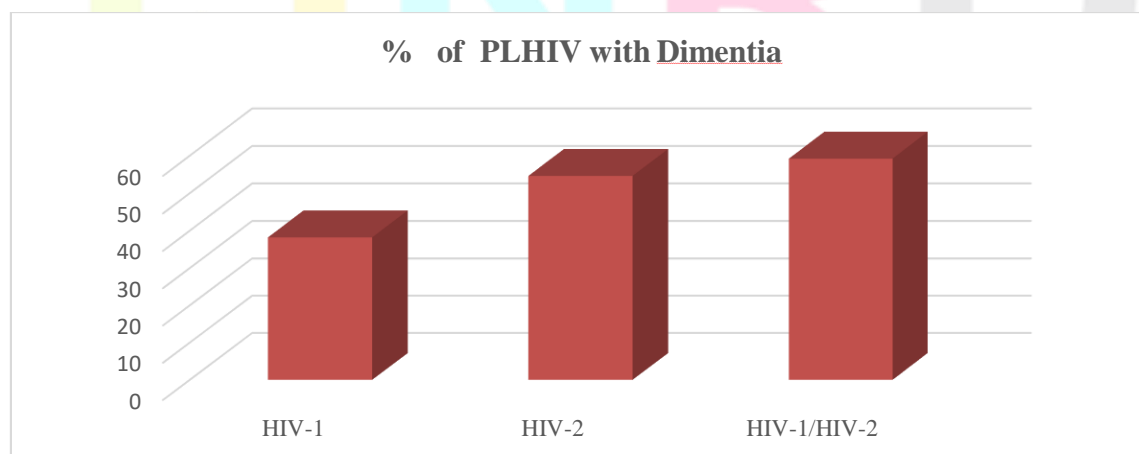
3.3. Associations between Participants characteristics and occurrence of HIV- dementia

After adjusting age, sex, level of education, marital status, monthly income, occupation, baseline CD4, weight and baseline viral load; PLHIV-2 had 1.81 fold increased risk of dementia (RR 1.81, 95% CI 1.33 to 2.36) compared with PLHIV-1 patients, and 1.71 fold high risk of dementia among patients with PLHIV- 1+2 infection (RR 1.71, 95% CI 1.27 to 2.29) compared with PLHIV-1. Age also was associated with dementia for age 42-55 years 1.51 (1.05-2.17) and age group >55 years 2.12 (1.34-3.35).

Table 2: Associations between Participants characteristics and occurrence of HIV- dementia

Variables	Number of individual N	Number with Dementia n (%)	Crude RR (95% CI)	Adjusted RR (95% CI)
	300	132 (44)		
HIV-subtype				
HIV-1	207	79 (38.2)	Ref	Ref
HIV-2	44	24 (54.6)	1.43 (1.04-1.97)	1.81 (1.33-2.36)
HIV-1/HIV-2	49	29 (59.2)	1.55 (1.16-2.07)	1.71(1.27-2.29)
Age				
11-25 yrs	65	22 (33.9)	Ref	Ref
26-40 yrs	97	35 (36.1)	1.07 (0.69-1.64)	0.96 (0.63-1.45)
41-55 yrs	114	58 (50.9)	1.50 (1.02-2.21)	1.51 (1.05-2.17)
>55 yrs	24	17 (70.8)	2.09 (1.37-3.20)	2.12 (1.34-3.35)
Sex				
Male	140	56 (40.0)	Ref	
Female	160	76 (47.5)	1.19 (0.92-1.54)	
Education level				
Primary	163	76 (46.6)	Ref	Ref
Secondary	95	34 (35.8)	0.77 (0.56-1.05)	0.80 (0.59-1.09)
College	15	2 (13.3)	0.29 (0.08-1.05)	0.24 (0.06-1.06)
None	27	20 (74.1)	1.59 (1.20-2.10)	1.36 (0.99-1.85)
Marital status				
Single	98	42 (42.9)	Ref	
Married	92	38 (41.3)	0.96 (0.69-1.35)	
Widow	42	26 (61.9)	1.44 (1.04-2.01)	
Cohabited	6	3 (50.0)	1.17 (0.51-2.68)	
Divorced	62	23 (37.1)	0.87 (0.58-1.29)	
Occupation				
Employed	52	18 (34.6)	Ref	
Self employed	170	68 (40.0)	1.16 (0.76-1.75)	
Unemployed	78	46 (59.0)	1.70 (1.12-2.58)	
Monthly Income				
<10,000	168	81 (48.2)	Ref	
10,000-100,000	72	35 (48.6)	1.01 (0.76-1.34)	
100,000-500,000	50	14 (28.0)	0.58 (0.36-0.93)	
>500,000	10	2 (20.0)	0.41 (0.12-1.45)	
CD4 group				
< 350	206	96 (46.6)	Ref	
> 350	94	36 (38.3)	0.82 (0.61-1.10)	
Median Weight (IQR)	59.5 (52-67)	58 (52-67)	0.999(0.997-1.003)	1.001 (0.998-1.004)
VL				
<1000	99	48 (48.5)	Ref	
>1000	201	84 (41.8)	0.86(0.66-1.12)	

4.2. DISCUSSION

The findings demonstrate variation of the occurrence of HIV dementia in relation to the HIV types for PLHIV based on ART-1 in Njombe and Dar es salaam. HIV-2 and HIV 1+2 dual infections was associated with higher risks of occurrence of the HIV-dementia to PLHIV with either HIV-2 or HIV-1+2 dual infections nearly two times higher. Older age was also associated with dementia which is not surprised as dementia occur mostly with aging.

This results was similar to the study conducted by Ned Sacktor et al. 2020 in Uganda which shown the use of specific ART regimen for PLHIV infected with different HIV types had a significant decrease in the frequency of cooccurrence of the dementia and other associated neurocognitive disorders [14,15]. Thus improvement of the ART treatment options based on the type should be in place in place together with monitoring for disease progression. There should be a back-up option for people using HIV-1 ART option in case of no responses based on the subtypes.

The increased risk observed may be due to higher plasma immune activation [16]. In a previous study from Senegal , HIV viral load was associated with risk of the occurrence of the HIV dementia at both baseline and follow-up suggesting that ongoing central nervous system viral replication may contribute to HIV dementia pathogenesis, and that the brain may constitute a reservoir for HIV which is an important target in future viral eradication strategies [17]. The highest frequency of the HIV-patients with HIV dementia was observed to those who were infected with HIV-1+2 dual infection followed by those infected with HIV-2 only. High CD4 count and low viral loads copies to the HIV- patients infected with HIV-2 and HIV 1+2 dual infection decreased the risk for occurrence of the HIV dementia although this was not significant, however, this might be due to the fact there is low response of the HIV-1 ART regimen to HIV-2 and HIV1+2 dual infections. The results conquer with study conducted by Prince PD, Matser A et al 2018 in Senegal that have shown the decrease HIV/AIDS dementia to HIV-2 and HIV 1+2 dual infection due to use of HIV-2 ART regimen [16]. Therefore need for use of the HIV-2 and HIV 1+2 ART regimen for HIV patients infected with specific subtypes is important to reduce the risk of occurrence of the HIV- Dementia.

Older age and economic status for unemployment were observed to be perpetuating factor that increased the risks of the HIV dementia. The study shown that the older age were independently associated with occurrence of the HIV dementia. Knowing dementia is also common to people with older ager, this might also be the reason for increased risk in additional to the HIV-1 ART regime. The immune system in older age and aging might affect the ability of the immune system to suppression of the virus leading to the increase of the viral load and increased risk of occurrence of the dementia among the infected individual results was similar to the study conducted by Saini S, Barar KV et al (2014) and Tsegaw M et al.2017 [18,19,20] that asses neurocognitive functions in HIV/AIDS patients and shown that age, sex , economic status and marital status were among the factors for occurrence of the neurocognitive disorders among PLHIV[19]

5.0. CONCLUSION AND RECOMMENDATION

I. The study findings underly the association of the HIV-1, HIV-2 and HIV1+2 dual infection on the occurrence of the HIV dementia. In general the study documented high risks of the occurrence of the HIV dementia in their course of HIV treatment HIV patients infected with HIV-2 and HIV 1+2 on HIV-1 ART drug for HIV treatment might need a close observation and follow up for dementia as getting older beyond 40 years. Age and economic status had relationship with the cooccurrence of HIV dementia. Therefore, the study recommend the use of the proper ART regimen for treatment of HIV-2 and HIV 1+2 dual infection to reduce the occurrence of the HIV-dementia among PLHIV.

6.0. ETHICAL CONSIDERATION

II. The study ethical clearance sought from **KNCHREC,** whereby the permission to conduct the study were sought from the Regional Medical Officers (RMO) of the Dar es Salaam and Njombe regions where the study took place. Written informed consent were provided to those who agreed to participate. For purpose of maintaining confidentiality, the unique identification number was assigned to each participant's questionnaire

7.0. DISCLOSURES AND ACKNOWLEDGEMENTS:

REFERENCES

[1] UNAIDS report on the global AIDS epidemic.. 2018

[2] UNAIDS report on the global AIDS epidemic.. 2021

[3] Tanzania National Aids Control Program NACP)report . 2018.

[3] Tanzania National Aids Control Program NACP)report . 2021

[4] Kiwanuka N, Laeyendecker O, Robb M, Kigozi G, Arroyo M, McCutchan F, et al. Effect of human immunodeficiency virus Type 1 (HIV-1) subtype on disease progression in persons from Rakai, Uganda, with incident HIV-1 infection. The Journal of infectious diseases. 2008;197(5):707–13. [PubMed: 18266607]

[5] Sacktor NC, Lyles RH, Skolasky RL, Anderson DE, McArthur JC, McFarlane G, et al. Combination antiretroviral therapy improves psychomotor speed performance in HIV-seropositive homosexual men. Multicenter AIDS Cohort Study (MACS). Neurology. 1999;52(8):16407

WHO report 2017

[6] Becker JT, Lopez OL, Dew MA, Aizestein HJ: Prevalence of cognitive disorders differs as a function of age in HIV virus infection. AIDS. 18 (1): 11-18.

[7] Fernandes, N. and Pulliam, L. (2019) Inflammatory Mechanisms and Cascades Contributing to Neurocognitive Impairment in HIV/AIDS. In: Cysique, L.A., Rourke, S.B., Eds., Neurocognitive Complications of HIV-Infection. Current Topics in Behavioral Neurosciences, Springer Nature, Switzerland, 77-103.

[8]Liu, T., Tan, J.Y., Hou, Z.J., et al. (2020) Research Progress on Pathogenesis and Diagnosis of HIV Related Neurocognitive Dysfunction. China AIDS STD, 26, 317-320

[9] Juliet Nakku, Eugene Kinyanda & Susan Hoskins (2018) Prevalence and factors associated with probable HIV dementia in an African population: Clinic population volume 13.

[10]Azan A Nyundo (2023).Correlates of the HIV-associated neurocognitive disorders among adults living with HIV in Dodoma region, central Tanzania PLoS One2023 May 25;18(5):e0285761.

[11] National Population Cencus,2022

[12] WHO AIDS-Dementia Assessment tool (2012)

[13] The International HIV-Dementia Scale; A new rapid screening test for HIV dementia (2015)

[14] Ned Sacktor, MD1, D et al. 2020. Effect of HIV Subtype and Antiretroviral therapy on HIV-associated neurocognitive disorder (HAND) stage in Rakai, Uganda

[15] Sacktor N, Nakasujja N, Skolasky R, Robertson K, Wong M, Musisi S, et al. Antiretroviral therapy improves cognitive impairment in HIV+ individuals in sub-Saharan Africa. Neurology. 2006;67(2):311–4. [PubMed: 16864825]

Yitbarek GY, Ayehu GW, Ayele BA, Bayih WA, Gebremariam AD, Tiruneh SA. [16] Cognitive impairment and its associated factors among HIV/AIDS patients on anti retro-viral therapy in Sub-Saharan Africa: systematic review and meta-analysis. Neurol Psychiatry Brain Res. (2020) 38:83–91. doi: 10.1016/j.npbr.2020.11.002

[17] Tsegaw M, Andargie G, Alem G, Tareke M. Screening HIV-associated neurocognitive disorders (HAND) among HIV positive patients attending antiretroviral therapy in SouthWollo, Ethiopia. J Psychiatr Res. (2017) 85:37–41.

[18] Engedal K, Haugen PK. The prevalence of dementia in a sample of elderly Norwegians. Int J Geriatr Psychiatry. (1993) 8:565–70.

[19] Shimizu SM, Chow DC, Valcour V, Masaki K, Nakamoto B, Kallianpur KJ, et al. The Impact of Depressive Symptoms on Neuropsychological Performance Tests in HIV-Infected Individuals: A Study of the Hawaii Aging with HIV Cohort. World journal of AIDS. 2011;1(4):139–45. [PubMed: 23061029]

[20] Joska JA, Dreyer AJ, Nightingale S, Combrinck MI, De Jager CA. Prevalence of HIV-1 Infection in an elderly rural population and associations with neurocognitive impairment