Asian Journal of Medicine and Health

Volume 21, Issue 7, Page 56-64, 2023; Article no.AJMAH.98696
ISSN: 2456-8414

Prevalence and Management of Helminthiasis and Virological Outcomes among HIV Co-infected Under-fives: A Case Study of Mwananyamala Hospital, Tanzania

Odino Brighton Ng'ondya [a], Raphael Zozimus Sangeda [a] and Kennedy Daniel Mwambete [a*]

[a] Department of Pharmaceutical Microbiology, Muhimbili University of Health and Allied Sciences, P.O. Box 65013, Dar es Salaam, Tanzania.

Authors' contributions

This work was carried out in collaboration among all authors. Author KDM designed the study, performed the statistical analysis and wrote the protocol. Author OBN collected data, wrote the first draft of the manuscript and managed literature search while author RZS managed the analyses of the study and performed a thorough review of the manuscript. All authors have read and approved the final manuscript.

Article Information

DOI: 10.9734/AJMAH/2023/v21i7831

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/98696

Original Research Article

Received: 12/02/2023
Accepted: 14/04/2023
Published: 21/04/2023

ABSTRACT

Background: Helminthiasis (HL) is a parasitic infection caused by worms that infect human body. The disease affects different regions of the world, but it is more prevalent in sub-Saharan African countries. A strong association between immunological status and helminthiasis among under-fives living with HIV infection (ULHI) has been reported.

**Corresponding author: E-mail: kmwambete@muhas.ac.tz;*

Aim: The study aimed to assess the prevalence and management of helminthiasis and virological outcomes among ULHI receiving health care at the Care and Treatment Centre (CTC) located at Mwananyamala Regional Referral Hospital (MRRH) in Dar es Salaam, Tanzania.
Methodology: This was a retrospective and descriptive cross-sectional study involving scrutiny of the clinical records of ULHI, who sought medical attention at MRRH. The clinical records were randomly selected and examined, focusing on the prevalence rate of HL, the co-management of HIV and HL infections, the virological outcome based on the HIV viral load, and other relevant data.
Results: A total of 499 ULHI were involved; of those, 254 (50.9%) were females and 245 (49.5%) were males. About 49% of the ULHI had HL. The prevalence of HL and the age of ULHI were both associated with the virological outcome (HVL). ULHI with lower HVL had a relatively greater HL prevalence. The most widely utilized antihelmintics were ABZ, MBZ and IVE, in that order. The most frequently prescribed drugs for co-infections were ABZ-ALL and MBZ-TLD combinations, which exhibited lower HVL.
Conclusion: Helminthiasis is still prevalent among ULHI, and use of prophylactic antihelminthics was associated with virological success (lower HVL). The prevalence of HL was relatively higher among ULHI with lower HVL.

Keywords: Helminthiasis; HIV infection; under-five children; virological outcomes.

ABBREVIATIONS

ULHI : Under five living with HIV infection
HL : Helminthiasis
CTC : Care and Treatment Centre
MRRH : Mwananyamala Regional Referral Hospital
HVL : viral load (virological outcome)
ARV : Antiretroviral
ART : Antiretroviral therapy
ABZ : Albendazole
IVE : Ivermectin
MBZ : Mebendazole
ALA/R : Abacavir, Lamivudine, Atazanavir/ Ritonavir;
ALD : Abacavir, Lamivudine, Dolutegravir
ALL : Abacavir, Lamivudine, lopinavir
TLD : Tenofovir, Lamivudine, Dolutegravir
ZLA : Zidovudine, Lamivudine, Abacavir
ZLL/R : Zidovudine, Lamivudine, Lopinavir /Ritonavir

1. INTRODUCTION

Human immunodeficiency virus (HIV) infection is considered one of the leading causes of death among children under five years old in countries with a high prevalence of HIV infection. Globally more than 90% of all HIV infections among children are caused by vertical transmission from infected mothers during gestation, delivery, postpartum, and breastfeeding [1,2]. In Tanzania, data on mothers and newborns infected with HIV using antiretroviral therapy (ART) scaled up from 2010-2018 [3]. However, linkage to care after diagnosis remains one of the weakest points of the national HIV infection prevention and control programmes [3-5]. Medical attention and adherence to ART in years after diagnosis of HIV infection are still one of the stumbling blocks in the health care system in our country. Of the numerous influencing factors, stigma and coverage of healthcare delivery plays a main role in this vast country [6,7].

Helminthiases are common infections caused by soil-transmitted helminths, namely *Ascaris lumbricoides, Trichuris trichiura, Necator americanus, Ancylostoma duodenale,* schistosomes and filarial worms which infect more than one billion people worldwide, rivaling HIV and malaria [8,9]. The disease is very prevalent in Sub-Saharan African countries such as Tanzania, where the infections are more prevalent among ULHI due to deteriorated capacity to fight infections [10-13]. Generally, HL is one of the neglected tropical diseases and therefore lacks more stringent measures to fight parasitic HL-associated infections [14-16]. Several clinical complications may arise as a result of chronic HLs, such as abdominal pain and diarrhea, inflammation of the bile duct system, liver abscess, acute pancreatitis, appendicitis and suffocation are common [17,18].

There may be interactions between HL and HIV coinfection, according to several research. It appears that Tanzania is geographically and socio-demographically comparable to the nations that are affected by both HIV and HL (3, 10 -13). There is, however, a dearth of information in these contexts that explores the relationship between HL and HIV coinfection, particularly the virological outcomes in patients receiving ART

[10,19,20]. Routine virological determination by HIV viral load (HVL) monitoring has been adopted by Tanzania's Standard HIV Treatment Guidelines from the WHO (21), which specifies that virological success occurs when the HIV-1 RNA level is less than 1,000 copies/mL and vice versa.

It is still unknown whether HLs impact variations in susceptibility to HIV infection [11,14]. However, it is evident that immune deficiencies with various etiologies can affect parasitic infections in diverse ways [21,22]. Strongyloidiasis is a case where this is more obvious because HIV co-infection has the opposite effect on parasite growth than other types of immunosuppression, like immunosuppression medications [23,24]. Therefore, the purpose of this research was to evaluate HL management among HIV co-infected under-five children and its association to virological outcomes.

2. METHODOLOGY

2.1 Study Design and Population

This was a retrospective cross-sectional study conducted between November 2020 and April 2021 in the CTC health care at MRRH. The study population consisted of children under-fives years of age living with HIV and treated with ARV for 22 months (January 2019 to October 2020).

2.2 Data Collection and Statistical Analysis

A sampling frame of 680 medical records was per-determined based on time and availability of resources. Each file was assigned one number between one and 680, and then 499 files were randomly picked using the Random Number Generator software. Each file was analyzed focusing on the following key aspects: demographic characteristics, diagnosis, viral load, ART, usage of the anthelminthic, presence of HLs, amount of visits/attendance at the CTC and other relevant information related to the study's aim were recorded. Virological success, was scored based on the viral load measurement below the cutoff limit of 1000 copies of viral plasma per cubic millimeter.

Data were analyzed by using SPSS version 22 software. Descriptive statistics, one-way ANOVA, logistic regression and Pearson's correlation, were performed to determine the correlation and association among the analyzed dependent and independent variables. Differences among individuals and between groups were regarded as significant when $p < .05$.

2.3 Exclusion and Inclusion Criteria

Only data within the specified period was collected. Files that missed more than two of the investigated variables were excluded. Only files of patients aged between one year and five years old were included. Files without a specific date of initiation of ART and the last visit to the CTC were excluded.

3. RESULTS AND DISCUSSION

In the present study, a total of 499 ULHI between 1 and 5 years of age attending CTC at MRRH in Dar es Salaam were enrolled. Of those, 254 (50.9%) and 245 (49.5%) were females and males, respectively. Virological failure was considered to have occurred when HVL exceeded 1000copies/mL in two consecutive measurements within a 3-month interval with adherence support after at least six months of following ART [25,26]. ART failure is now recognized as associated with virological, immunologic, and/or clinical failure [27–29].

Slightly less than half (48.9%) of the studied ULHI were co-infected with HLs. Our findings coincide with those of a previous study conducted over a decade ago in Tanzania, indicating that half of the studied population of ULHI harbored HLs [10]. In line with our most recent results, there were no appreciable variations in the prevalence rates of HLs between male and female ULHI nor among age groups of ULHI, as depicted in Table 1. Contrary to our observations, a study from Rwanda found that male children had higher prevalence rates than female children [30]. Likewise, a significant association between the prevalence of HL and the age of ULHI was observed ($X^2 = 7.828$; df = 2; $p = .02$). This coincides with studies done in Uganda that suggest that HLs increase with age [31].

HIV-infected children face a lifetime of treatment because of the persistent nature of HIV. Several studies indicate that the earlier effective combination ART is initiated, the smaller the size of the HIV reservoir and/or viremia [26, 32]. Our findings showed no association between the sexes of ULHI and HVL. However, a statistically significant association was revealed

between the prevalence of HLs and HVL (X^2=195.120; df = 471; p < .01), as indicated in Table 2.

According to the research, the majority of ULHI (87.3%) had virological success, which is less than the threshold of 1000 viral plasma copies per cubic millimeter, as shown in Table 3. Given that the majority of them (73%) frequently received medical care, this might be the result of their high CTC attendance. Time-lapse or attendance at CTC was found to be statistically significantly correlated with the frequency of HL (p-value = .01). The frequency of visiting the CTC was inversely correlated with a decline in the prevalence of rates of HL (contraction of HLs).

A regular CTC attendee, had a 2.079 times lower risk of developing HLs (p< .01). Nevertheless, between HL-infected and uninfected ULHI, the effects of CTC attendance and the virological outcome were similar (Fig. 2). While there was a negative association (Pearson's R = -0.217; p < .01) between virological outcomes (HVL) and trends of CTC attendance.

Slightly less than half (48.9%) of the ULHI under study had HLs as well. Our results support those of earlier research carried out in Tanzania more than ten years ago, which found that HLs were present in half of the ULHI population [10]. In our study, more than half (51.7%; n = 253) of the ULHI were taking prophylactic antihelminthic medication. The majority of them (85.4%) used ABZ (Table 3). An association was observed between antihelminthics usage in relation to age group and virological outcome/HVL (X^2 = 23.281; df = 6; p = .001). The majority (88.0%) of the ULHI with low HVL were taking prophylactic antihelminthics (ABZ, MBZ, and IVE). Of 499 ULHI, 12% (n = 60) had HVL higher than 1000 copies per millimeter square (Table 3). The co-infections with HIV and HLs were regularly treated by ABZ-ALL and MBZ-TLD. But TLD was combined with all three antihelminthics. ULHI receiving a combination of MBZ-ZLL/R, ABZ-TLD, and IVE-TLD exhibited a low HVL (virological outcome) as depicted in Fig. 1.

Our study showed that ULHI treated with ART and anthelminthics had better virological outcomes (lower HVL) than those treated with

Table 1. Characteristics of the study population and prevalence of HLs

Variables		Contracted HI (%)		P-value (X^2)
		No	Yes	
Sex	Female	121 (24.25)	133 (26.65)	0.140
	Male	134 (26.85)	111 (22.24)	
Age group	0-2	6 (1.2)	19 (3.8)	
	3-4	59 (11.8)	56 (11.2)	0.02
	5-6	190 (38.1)	169 (33.9)	
Attendance to CTC (months)	1-2	219 (43.9)	142 (28.5)	
	3-4	28 (5.6)	72 (14.4)	0.001
	5-6	8 (1.6)	30 (6.0)	

Table 2. Contraction of HLs in relation to virological outcome (HVL) among ULHI

Virological outcome (Cut off 1000 copies/ml)	Contracted HI (%)		Total
	No	Yes	
Success	163 (73.1)	251 (100.0)	414 (87.3)
Failure	60 (26.9)	0 (0.0)	60 (12.7)
Total	223 (47.0)	251 (53.0)	474 (100.0)

Table 3. Usage of antihelminthics and HVL among the ULHI

Virological outcomes (copies/ml)	Antihelminthics (%) n=474*				P-value
	None	ABZ	IVE	MBZ	
Success (0-1000)	161(34.0)	216 (45.5)	19 (4.0)	18 (3.8)	
Failure (>1000)	60 (12.7)	0 (0.0)	0 (0.0)	0 (0.0)	
Total	221 (46.7)	216 (45.5)	19 (4.0)	18 (3.8)	0.001

(*) A total of 25 (5%) of the children had no records of HVL

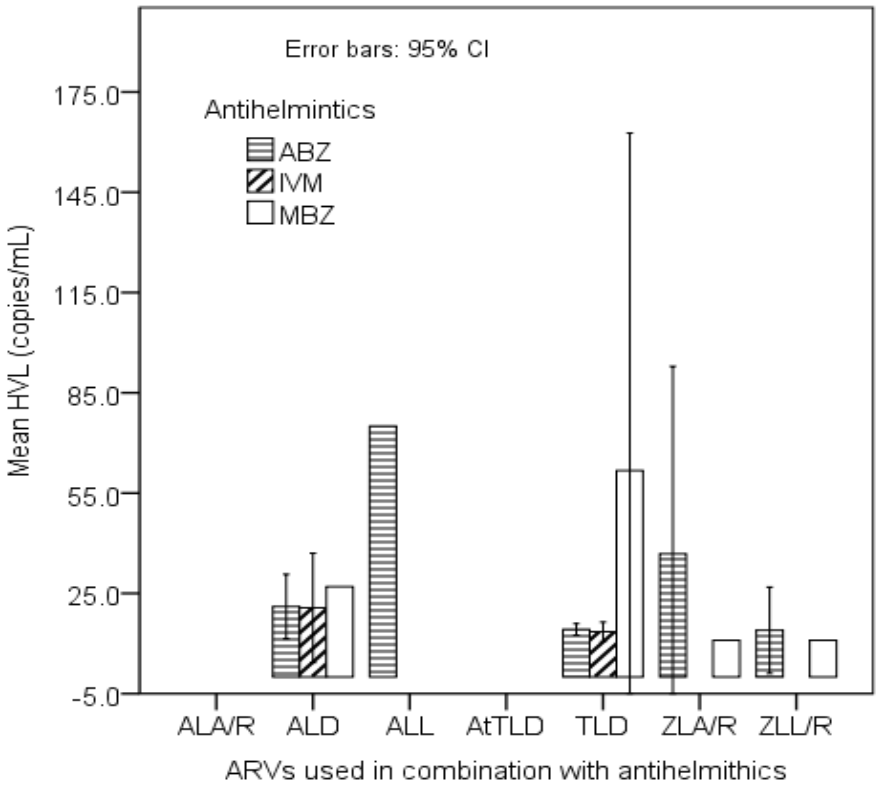

Fig. 1. Co-management of helminthic and HIV infections among the studied ULHI

Key: *ALA/R - Abacavir, Lamivudine, Atazanavir/Ritonavir; ALD – Abacavir, Lamivudine, Dolutegravir; ALL- Abacavir, Lamivudine, lopinavir; TLD-Tenofovir, Lamivudine, Dolutegravir; ZLA- Zidovudine, Lamivudine, Abacavir; ZLL/R- Zidovudine, Lamivudine, Lopinavir /Ritonavir*

only one therapy. Low HVL, a marker of virological success, points to higher amounts of CD4+ T cells, which typically regulate the immune system's regular operation. It is also recognized that anthelminthic therapy significantly improves ART in terms of immune function and viral replication prevention [33]. Contrary to the WHO's recommendation, IVE was administered to some patients in this research. The WHO recommends using ABZ, MBZ, levamisole, and pyrantel for the treatment of human HLs [34]. Several animal and human viruses, have shown susceptibility to the broad-spectrum antiviral action of ivermectin [35]. This partly explains the observed success in virological outcomes among ULHI treated with a combination of IVE-TLD in our study. TLD was the most commonly used ART combination, and ULHI getting TLD therapy showed improved virological results (lower HVL) coinciding with the previous observation by [36].

Despite this close pathophysiological relationship, there is a general dearth of information on how HIV and HLs interact, particularly in the era of widely accessible ART [11, 12, 34]. The prevalence rate of HLs was slightly higher among ULHI, who had lower HVL (Tables 2 and 3). It was observed that 206 ULHI had just initiated the ART at the CTC, which also featured as the first month of visit. Of those, 43 (20.9%) of the ULHI manifested virological failure. A total of 37 ULHI had not been to CTC in more than four months, but none manifested virological failure (Fig. 2). In the study population, there was a clear correlation between the number of CTC visits and HVL (X^2 = 86.83; df = 30; p 0.001).

HLs may inhibit the Th1 cell response directly, resulting in a decrease in CD8+ cytotoxic T lymphocytes (CTL), which are required to combat HIV [11]. In humans, the virological outcome is directly linked to HIV-specific CTL responses, and a decrease in CTL responses is associated with a faster progression of HIV infection [10]. It's possible that changes in immune regulation caused by HIV replication will produce more visible changes in HVL levels after HL or eradication. This could explain why 12.7% of ULHI who were not taking antihelminthics experienced virological failure.

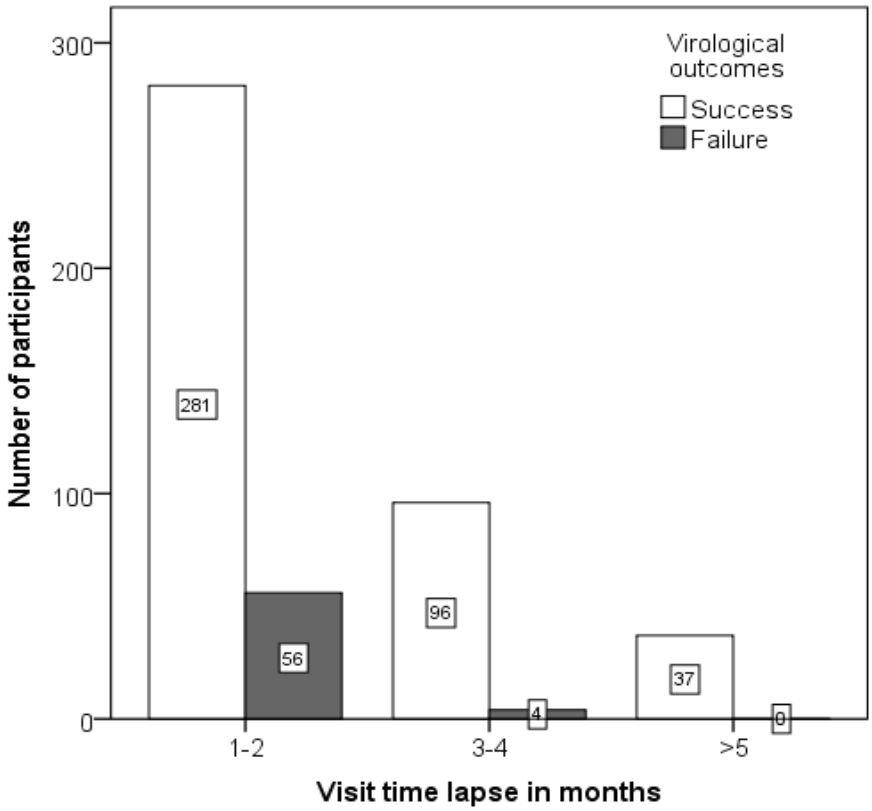

Fig. 2. Virological status among ULHI in relation to the length of visits to CTC

In this instance, the observed high rate of HLs among ULHI with virological success (low HVL) could be attributed to cellular immunity activation (CTL). Numerous investigations on the relationship between HIV/AIDS and HL have currently produced contradictory results [10, 13, 36]. One of the characteristics of HIV infection, which is widespread and closely matches people with HLs, is chronic immune activation [11, 13]. As a consequence, ULHI with HL will unquestionably experience a quicker decline in health and may develop AIDS earlier [10, 13].

4. CONCLUSION

Helminthiasis is still prevalent among ULHI, albeit with no significant statistical difference between males and females. ULHI that experienced virological success (lower HVL) were more likely to acquire HLs than those that did not. Majority of ULHI with lower HVL were treated with ABZ, MBZ and IVE. ABZ-ALL and MBZ-TLD were the most frequently used combination therapies for managing HL-co-infected ULHI. The virological success was achieved using the combination of MBZ-ZLL/R, ABZ-TLD, and IVE-TLD. ULHI, who frequently visited the CTC for medical care, experienced a marked decline in HLs. Anthelmintic prophylactic chemotherapy should be given to ULHI more regularly to avoid HLs and enhance the well-being of the children. Studies need to be conducted to determine how HLs affect the decline in virological outcomes observed in the current study. We recommend comparing ULHI and HIV-negative under-fives to look into different factors that may shed light on some still-unresolved issues.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The ethical clearance was sought from the MUHAS Research and Publications Ethical Committee, preceded by approval from the School of Pharmacy Research Dissemination Committee. Permission to access the medical records was then obtained from the MRRH authority. Confidentiality was strictly observed by not disclosing the collected personal information.

ACKNOWLEDGEMENTS

The Department of Pharmaceutical Microbiology (MUHAS) and the Ministry of Education and Vocational Training provided the authors with technical and financial support, respectively.

They also thank the MUHAS ethical committee and the MRRF authority for allowing them to carry out this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, Cousens S, Mathers C, Black RE. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. The lancet. 2015 Jan 31;385(9966):430-40. Available:http://dx.doi.org/10.1016/S0140-6736(14)61698-6.
2. Chilaka VN, Konje JC. HIV in pregnancy–An update. Eur J Obstet Gynecol Reprod Biol. 2021 Jan; 256: 484–491. DOI: 10.1016/j.ejogrb.2020.11.034
3. Teasdale CA, Abrams EJ, Yuengling KA, Lamb MR, Wang C, Vitale M, Hawken M, Melaku Z, Nuwagaba-Biribonwoha H, El-Sadr WM. Expansion and scale-up of HIV care and treatment services in four countries over ten years. PloS one. 2020 Apr 16;15(4):e0231667. DOI: https://doi.org/10.1371/journal.pone.0231667
4. Anderson SJ, Cherutich P, Kilonzo N, Cremin I, Fecht D, Kimanga D, Harper M, Masha RL, Ngongo PB, Maina W, Dybul M. Maximising the effect of combination HIV prevention through prioritisation of the people and places in greatest need: a modelling study. The Lancet. 2014 Jul 19;384(9939):249-56. DOI: 10.1016/S0140-6736(14)60164-1 PMID: 24907868
5. Mauka W, Mbotwa C, Moen K, Lichtwarck HO, Haaland I, Kazaura M, Leyna GH, Leshabari MT, Mmbaga EJ. Development of a mobile health application for HIV prevention among at-risk populations in urban settings in East Africa: a participatory design approach. JMIR Form Res. 2021 Oct 7;5(10): e23204. DOI:10.2196/23204.
6. Sangeda RZ, Mosha F, Aboud S, Kamuhabwa A, Chalamilla G, Vercauteren J, et al. Predictors of non-adherence to antiretroviral therapy at an urban HIV care and treatment center in Tanzania. Drug Healthc Patient Saf. 2018;10:79–88. DOI:10.2147/DHPS.S143178.
7. Kilapilo MS, Sangeda RZ, Bwire GM, Sambayi GL, Mosha IH, Killewo J. Adherence to antiretroviral therapy and associated factors among people living with hiv following the introduction of dolutegravir based regimens in Dar es Salaam, Tanzania. J Int Assoc Provid AIDS Care. 2022;21: 232595822210845. Doi:10.1177/23259582221084543
8. Mutoni JD, Coutelier JP, Rujeni N, Mutesa L, Cani PD. Possible interactions between malaria, helminthiases and the gut microbiota: a short review. Microorganisms. 2022 Mar 27;10(4):721. DOI: 10.3390/microorganisms10040721
9. Fauziah N, Ar-Rizqi MA, Hana S, Patahuddin NM, Diptyanusa A. Stunting as a Risk Factor of Soil-Transmitted Helminthiasis in Children: A Literature Review. Interdiscip Perspect Infect Dis. 2022 Aug 3;2022:8929025. DOI: 10.1155/2022/8929025.
10. Mwambete KD, Tunzo J, Justin-Temu M. Prevalence and management of helminthiasis among underfives living with HIV/AIDS at Amana Hospital, Tanzania. J Int Assoc Provid AIDS Care (JIAPAC). 2013 Mar;12(2):122-7. DOI: 10.1177/1545109712449865
11. Maizels RM, Yazdanbakhsh M. Immune regulation by helminth parasites: cellular and molecular mechanisms. Nat Rev Immunol. 2003;3:733–744. DOI: 10.1038/nri1183
12. Evans EE, Siedner MJ. Tropical parasitic infections in individuals infected with HIV. Current tropical medicine reports. 2017 Dec;4:268-80. DOI: https://doi.org/10.1007/s40475-017-0130-6
13. Chavura E, Singini W, Chidya R, Mbakaya BC. Immunological responses to helminths and HIV-1 co-infections. ESI Preprints. 2023 Jan 30;13:525. DOI: https://doi.org/10.19044/esipreprint.1. 2023. p525

14. Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J. Helminth infections: the great neglected tropical diseases. J Clin Invest. 2008 Apr;118(4): 1311-21.
DOI: 10.1172/JCI34261.
15. Sartorius B, Cano J, Simpson H, Tusting L, Marczak L, Miller-Petrie M, Kinvi B, Zoure H, Mwinzi P, Hay S, Rebollo M. Mapping soil-transmitted helminth infections of children in Sub-Saharan Africa, 2000-2018. Lancet Glob Health. 2021 Jan;9(1):e52-e60.
DOI: 10.1016/S2214-109X (20)30398-3.
16. Ojja S, Kisaka S, Ediau M, Tuhebwe D, Kisakye AN, Halage AA, Mugambe RK, Mutyoba JN. Prevalence, intensity and factors associated with soil-transmitted helminths infections among preschool-age children in Hoima district, rural western Uganda. BMC Infectious Dis. 2018 Dec;18(1):1-2.
DOI: https://doi.org/10.5888/pcd18.200248
17. Parija SC, Chidambaram M, Mandal J. Epidemiology and clinical features of soil-transmitted helminths. Trop Parasitol. 2017 Jul-Dec; 7(2): 81–85.
DOI: 10.4103/tp.TP_27_17
18. Chifunda K, Kelly P. Parasitic infections of the gut in children. Paediatr Int Child Health 2019 Feb;39(1):65-72.
DOI: 10.1080/20469047.2018.1479055.
19. Kayvon Modjarrad, Isaac Zulu, David T. Redden, Lungowe Njobvu, H. Clifford Lane, Zvi Bentwich, Sten H. Vermund. Treatment of intestinal helminths does not reduce plasma concentrations of HIV-1 RNA in coinfected zambian adults. The Journal of Infectious Diseases. 1 October 2005;192:7:1277–1283.
DOI: https://doi.org/10.1086/444543
20. Deku JG, Botchway KA, Kinanyok S, Gedzeah CK, Duneeh RV, Duedu KO. Intestinal parasitic infection and associated risk factors among HIV-infected patients seeking healthcare in a Rural Hospital in Ghana. J Pathog. 2022 Aug 22; 2022:5652637.
DOI: 10.1155/2022/5652637. eCollection 2022.
21. Organization WH. WHO | Consolidated guidelines on HIV prevention, diagnosis, treatment and care for key populations. WHO; 2017.
Available:
http://www.who.int/hiv/pub/guidelines/keypopulations/en/
22. Udeh EO, Obiezue RN, Okafor FC, Ikele CB, Okoye IC, Otuu CA. Gastrointestinal parasitic infections and immunological status of HIV/AIDS coinfected individuals in Nigeria. Ann Glob Health. 2019;85(1):99:1-7.
DOI: https://doi.org/10.5334/aogh.2554.
23. Mabbott NA. The influence of parasite infections on host immunity to co-infection with other pathogens. Front Immunol. 2018 Nov 8; 9:2579.
DOI: 10.3389/fimmu.2018.02579. eCollection 2018.
24. Viney ME, Lok JB. The biology of Strongyloides spp. WormBook. 2015 Jul 16;16:1-7.
DOI: 10.1895/wormbook.1.141.2.
25. Prasad KN, Sahu C. Strongyloidiasis. In: Parija, S.C., Chaudhury, A. (eds) Textbook of Parasitic Zoonoses. Microbial Zoonoses. Springer, Singapore; 2022.
DOI:https://doi.org/10.1007/978-981-16-7204-0_43
26. OARAC. Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection What's New in the Pediatric Guidelines; 2020.
Available:https://clinicalinfo.hiv.gov/en/guidelines/pediatric-arv.
27. Rainwater-Lovett K, Luzuriaga K, Persaud D. Very early combination antiretroviral therapy in infants: prospects for cure. Curr Opin HIV AIDS. 2015 Jan;10(1):4–11.
DOI: 10.1097/COH.0000000000000127
28. Kapesa A, Magesa D, William A, Kaswija J, Seni J, Makwaya C. Determinants of immunological failure among clients on the first line treatment with highly active antiretroviral drugs in Dar es Salaam, Tanzania. Asian Pac J Trop Biomed. 2014 Jul 1;4:S620-4. 4(supp 2):737-741.
DOI:10.12980/APJTB.4.2014APJTB-2013-0035
29. Brhane BG, Nibret E, Abay GK. HIV/AIDS treatment failure and its determinant factors among first line HAART patients at Felege-Hiwot Referral Hospital, Bahir Dar, Northwest Ethiopia. AIDS Clin Res. 2017;8.
DOI: 10.4172/2155-6113.1000744.
30. Kabatende J, Mugisha M, Ntirenganya L, Barry A, Ruberanziza E, Mbonigaba JB, Bergman U, Bienvenu E, Aklillu E. Prevalence, intensity, and correlates of soil-transmitted helminth infections among school children after a decade of

preventive chemotherapy in Western Rwanda. Pathogens. 2020 Dec 21;9(12):1076.
DOI: 10.3390/pathogens9121076.

31. Ojja S, Kisaka S, Ediau M, Tuhebwe D, Kisakye AN, Halage AA, Mugambe RK, Mutyoba JN. Prevalence, intensity and factors associated with soil-transmitted helminths infections among preschool-age children in Hoima district, rural western Uganda. BMC Infect Dis. 2018;18:408.
DOI: https://doi.org/10.1186/s12879-018-3289-0
32. Millar JR, Bengu N, Fillis R, Sprenger K, Ntlantsana V, Vieira VA, Khambati N, Archary M, Muenchhoff M, Groll A, Grayson N. High-frequency failure of combination antiretroviral therapy in paediatric HIV infection is associated with unmet maternal needs causing maternal non-adherence. E Clinical Medicine. 2020 May 1;22:
DOI: 10.1016/j.eclinm.2020.100344
33. Arts EJ, Hazuda DJ. HIV-1 antiretroviral drug therapy. Cold Spring Harb Perspect Med 2012 Apr;2(4): a007161.
DOI: 10.1101/cshperspect. a007161.
34. Farrell SH, Coffeng LE, Truscott JE, Werkman M, Toor J, de Vlas SJ, Anderson RM. Investigating the effectiveness of current and modified World Health Organization guidelines for the control of soil-transmitted helminth infections. Clin Infect Dis. 2018. June 1;66(suppl_4): S253–9.
DOI: https://doi.org/10.1093/cid/ciy002
35. Martin RJ, Robertson AP, Choudhary S. Ivermectin: an anthelmintic, an insecticide, and much more. Trends Parasitol. 2021 Jan;37(1):48-64.
DOI:10.1016/j.pt.2020.10.005.
36. Ivan E, Crowther NJ, Mutimura E, Rucogoza A, Janssen S, Njunwa KK, Grobusch MP. Effect of deworming on disease progression markers in HIV-1–Infected pregnant women on antiretroviral therapy: a longitudinal observational study from Rwanda. Clin Infect Dis. 2015 Jan 1;60(1):135-42.
DOI: 10.1093/cid/ciu715

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/98696