

Evaluation of the Prevalence, Progression and Severity of Common Adverse Reactions (Lipodystrophy, CNS, Peripheral Neuropathy, and Hypersensitivity Reactions) Associated with Anti-Retroviral Therapy (ART) and Anti-Tuberculosis Treatment in Outpatients in Zimbabwe

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Abstract

Introduction: The use of many anti-retroviral drugs has been associated with a myriad of adverse drug reactions (ADRs) which could limit successful treatment outcome with respect to patient compliance and quality of life. An additional consideration is the high incidence of HIV infection with tuberculosis (TB) in Southern Africa, including Zimbabwe, and the use of co-treatment regimens.

Methods: The study is a cross sectional, case-control study of 433 out-patients conducted at two hospitals in Zimbabwe. The patients were profiled for adverse reactions namely central nervous system side-effects (CNS), lipodystrophy (LD), skin hypersensitivity (SH), and peripheral neuropathy (PN). Assignment of the case and the control status of a patient was done based on occurrence of these adverse drug reactions in each of the HIV/AIDS only, TB only and HIV/TB co-infection patient groups.

Results: Among the HIV/AIDS only treatment group (n= 240), the incidences of major ADRs were PN (63%), LD (38%), CNS (29%) and SH (21%). In the TB only treatment group (n=92), the major ADRs were PN (49%), CNS (29%), and SH (14%). In the HIV-TB co-treatment group (n=98), the major ADRs were PN (64%), CNS (39%), LD (6%) and SH (18%). A significant number of females were on alternate first line treatment that has no stavudine as compared to males (OR=1.98, CI (1.1, 3.59); p=0.03). Occurrence of CNS adverse drug reactions were more associated with patients on efavirenz than other HIV-drug combinations (43% vs. 17%, p<0.00001).

Conclusion: The use of anti-retroviral drugs and anti-TB drugs is associated with very high incidences of adverse drug reactions. There is therefore need to understand the pharmacokinetic and pharmacodynamic mechanisms of these ADRs so as to identify patients at risk and to provide guidelines for the choice of drug and dosage to ensure safe and efficacious treatment outcomes.

Introduction

Sub-Saharan Africa carries the heaviest burden of the HIV and AIDS pandemic. Zimbabwe is within the epicentre of this pandemic with an HIV infection prevalence of 14.3% in the ≥ 15years age group [1]. The prevalence of Tuberculosis (TB), the major opportunistic infection causing death in HIV and AIDS patients is also high with 60-80% of TB patients being estimated to be HIV positive [1-3]. Sub-Saharan African populations were late in receiving anti-retroviral therapy (ART) resulting in high mortality rates among HIV and AIDS patients. Over the years, since 1985, HIV and AIDS overtook malaria as the leading cause of death in Africa [4].

High mortality rates due to HIV and AIDS declined in resource rich countries with the discovery and access to anti-retroviral drugs (ARVs), starting with zidovudine in 1985 [5]. Through the Global Fund and concerted efforts of nongovernmental organisations, access to ARVs steadily increased in Sub-Saharan Africa. In addition, the Zimbabwean government initiated the AIDS Levy for all workers in 1999 as a national response to the HIV/AIDS pandemic. The AIDS Levy is a percentage of taxable income (3%) taken from every Zimbabwean employee's salary per month and deposited into the National AIDS Council (NAC) account for use in programs to combat HIV/AIDS in Zimbabwe [6]. By 2008, over 1 million people were infected with HIV and 500 000 required ART, but only a modest 100 000 currently have access to these life-saving drugs [7]. Given the recent evidence that ART not only reduces mortality rates but also reduces transmission

rates [8], ART holds the promise to halting the spiral spread of the HIV pandemic.

The access to ARVs has not been without difficulties. Earlier use of monotherapy was associated with the emergence of drug resistant variants of HIV [9]. Research in the 1990s led to the discovery of the more effective highly active anti-retroviral therapy (HAART) [10,11]. The use of ARVs was and continues to be associated with moderate, severe and sometimes life threatening adverse drug reactions. For many patients there is a shift from limited access to ARVs to issues of safety and efficacy in their use. As the use of ARVs was accessed by many patients across the world and used for long

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periods, many side effects became apparent for some of the drugs [12].

In Zimbabwe, the 1st line therapy is composed of two nucleoside analogue inhibitors (chosen from stavudine, or zidovudine and lamivudine) and a non-nucleoside analogue inhibitor, Nevirapine or Efavirenz [6]. Zimbabwe is now phasing out stavudine in favour of tenofovir/ zidovudine as of April 2011 as per WHO treatment guidelines [13]. A number of studies are now appearing on safety in the use of ARVs in HIV/AIDS patients in Zimbabwe and other Sub Saharan African countries [14,15]. Such studies are important at patient level, so that patients are given drugs and doses that are safe and efficacious, and at national ARV procurement policy level, so that government procures the right drugs.

In this study, we have evaluated the prevalence, progression and severity of adverse effects to commonly used ARVs and anti-TB drugs in Zimbabwe. Subjects for the study were HIV/AIDS, TB and HIV-TB outpatients who had been on different treatment regimens and for different periods.

Materials and Methods

Study Population: A cross sectional, case-control, study of HIV/AIDS and/or TB-infected patients who attended the Chitungwiza and Wilkins Hospitals in Harare, Zimbabwe was conducted. Approval to conduct the studies was obtained from the Medical Research Council of Zimbabwe (MRCZ) and the respective Hospital Authorities. Patients participated voluntarily after signing the consent form. A total patient population of 433 was examined. HIV infected and HIV-TB co-infected patients paid two visits to the hospital. On the first day consent was obtained and blood samples collected for drug concentration and genotyping analyses. On the second day, the questionnaire was administered and another blood sample was collected. Patients with TB only and on anti-TB drugs paid one visit to the hospital for purposes of giving consent, responding to the questionnaire and blood collection. The inclusion criterion was that patients had to be adults (≥ 18 yrs of age) and HIV/AIDS and/or TB-infected. Patients too frail to undertake the required two visits and relatively long waiting times and examination procedures were excluded. The patients had to be on HIV/AIDS and/or TB treatment. Patients participated in the evaluation and physical examination for lipodystrophy, skin hypersensitivity, peripheral neuropathy and CNS side effects. Severity of adverse drug reactions were identified from grade 1 to 4 according to WHO guidelines (I-Mild, II-Moderate, III-Severe, and IV-Life Threatening, Table 1) [16,17]. Each patient provided information for a questionnaire which captured patient demographic information, medical history, and specific questions related to the 4 ADRs which are subject of evaluation

in this study. For each of the 4 adverse drug reactions evaluated, CNS, SH, LD and PN, the controls were those patients who showed no signs of a side effect both by self evaluation and the nurse's evaluation. For each of the 4 adverse drug reactions, cases were the ones who showed signs of a side effect both by self evaluation and the nurse's evaluation.

Statistical Analysis: Statistical analysis was done using R, and STATA. Means and medians (interquartile range) were used to describe parametric data and non-parametric data, respectively. Categorical data was compared using χ^2 test (or Fisher's exact test), and continuous data were compared using student's T-test or Mann-Whitney test, and Kruskal Wallis whichever was appropriate.

Results

Overview of ADRs

The enrolment attracted 433 patients but three were lost to follow up on the second day. A total of 430 patients (35% were males and 65% female) were therefore subsequently evaluated for ADRs. There were 240 patients on ART alone, 92 patients on TB treatment only, and 98 patients on both ART and anti-TB treatment. Of those on ART alone 69% were on a stavudine containing regimen and 31% on other combinations including tenofovir and zidovudine. Most of the ART group (59%) were on nevirapine as the NNRTI and 40% on efavirenz. Of those on both ART and TB treatment, 92% were on a stavudine containing treatment and 8% on other combinations including tenofovir and zidovudine. All on the HIV/TB co-treatment were on efavirenz as the NNRTI component of their treatment. All TB treatment regimens had isoniazid and rifampicin as part of the combination therapy.

Of the patients (n=55) on a zidovudine containing regimen, 40% had been transferred from stavudine treatment because of lipodystrophy and 27% because of peripheral neuropathy, with 11% due to both side effects. The frequencies of females who were on zidovudine containing regimens and on tenofovir containing regimens were 80% and 79% respectively. Considering patients who were on tenofovir containing regimen (n=29), 38% had been transferred from a stavudine containing regimen due to lipodystrophy and 31% due to peripheral neuropathy. A significant number of females (OR=1.98, CI (1.1, 3.59); p=0.03) compared to males were on the first line HIV/AIDS treatment that is the alternative to the stavudine containing treatment. The alternative first line treatment consisted of either tenofovir or zidovudine as substitutes of stavudine due to either peripheral neuropathy or lipodystrophy.

In this study we observed that 83% of the 430 patients on HIV/AIDS, HIV+TB and TB treatment exhibit at least one of the four adverse drug reactions (ADRs) evaluated, i.e. lipodystrophy, peripheral neuropathy, skin hypersensitivity reactions and central nervous systems

Adverse Drug Reactions (ADRs) and their characteristics	Grade 0	Grade I –Mild	Grade II- Moderate	Grade III- Severe	Grade IV-Life Threatening
Lipodystrophy: Fat gain/loss on different parts of body e.g. cheeks, lips, unusual fat redistribution. Skin Hypersensitivity: Skin rashes, Skin colour changes, Itchiness. CNS ADRs: Hallucinations, Headaches, Insomnia. Peripheral Neuropathy: Numbness, tinginess, pain at ends e.g. fingers.	No reporting of ADR's	Symptoms causing no or minimal interference with usual social & functional activities.	Symptoms causing greater than minimal interference with usual social & functional activities.	Symptoms causing inability to perform usual social and functional activities.	Symptoms causing inability to perform basic self-care functions OR Medical or operative intervention indicated to prevent permanent impairment, persistent disability or death.

Table 1: Summarised characteristics and classification of ADRs in patients on ARV's and/or TB drugs.

effects. Table 2 shows the percentage frequency of patients reporting the number of ADRs they were experiencing.

Table 3 shows summary statistics of ADRs evaluated in this study. For the HIV/AIDS only treatment group, the major ADRs were peripheral neuropathy (63%), lipodystrophy (38%), CNS side effects (29%) and skin hypersensitivity (21%). The most common side effect

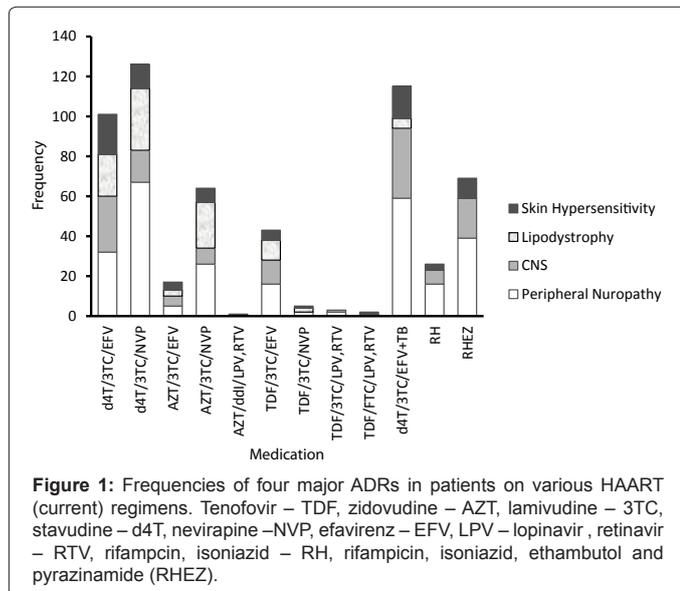


Figure 1: Frequencies of four major ADRs in patients on various HAART (current) regimens. Tenofovir – TDF, zidovudine – AZT, lamivudine – 3TC, stavudine – d4T, nevirapine – NVP, efavirenz – EFV, LPV – lopinavir, ritonavir – RTV, rifampicin, isoniazid – RH, rifampicin, isoniazid, ethambutol and pyrazinamide (RHEZ).

for those on ART and TB treatment was peripheral neuropathy for 64% of patients, followed by CNS side effects (39%), lipodystrophy (6%) and skin hypersensitivity (18%). For the patients on TB treatment only, 60% had a degree of peripheral neuropathy with the majority (62%) reporting this at grade I level. The prevalence of other side effects for the TB treatment group was 14% for skin hypersensitivity and 29% for CNS side effects. Taking into consideration individuals on ART, only 13% reported absence of any of the four side effects evaluated in this study. This group were of a relatively lower median age (36yrs vs. 40yrs, p=0.07) compared to the group that had at least one side effect. Odds of females to males having at least one of the side effects due to ART treatment were slightly higher (OR=1.85(0.91, 3.69): p=0.059). Those who had developed at least one of the evaluated side effects were on a relatively longer mean time on medication (15months vs. 21 months: p=0.062). The above results for differences in age, gender and time on medication, however, show no statistical significance at 5% level for the characteristics investigated.

Figure 1 presents the ADRs data to demonstrate the frequency of each ADR under each of the treatment regimens of the 430 patients. The frequencies of ADRs for d4T/3TC/NVP were in the following decreasing order PN>LD>CNS>SH and for those on d4/3TC/EFV+TB (RHEZ/RH) the frequencies were PN>CNS>SH>LD. For patients on TB treatment alone the frequencies of ADRs were in the following decreasing order PN>CNS>SH.

Lipodystrophy

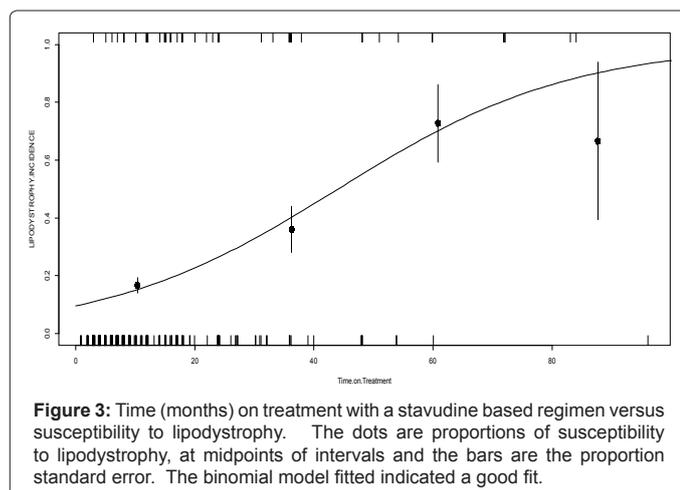
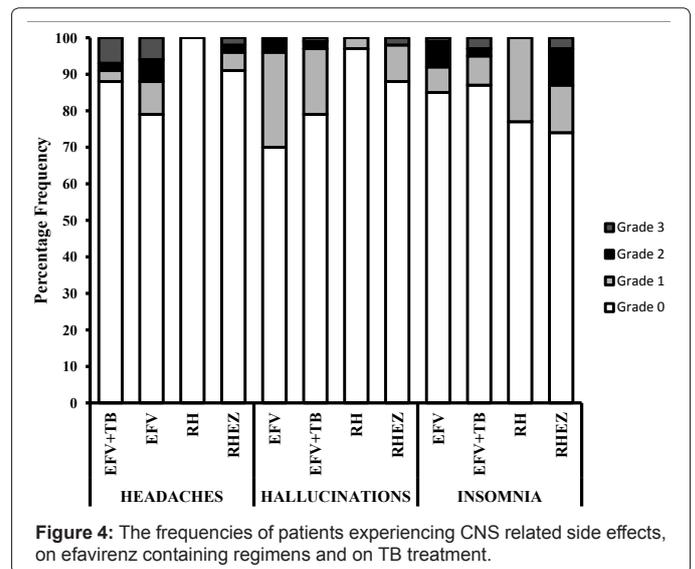
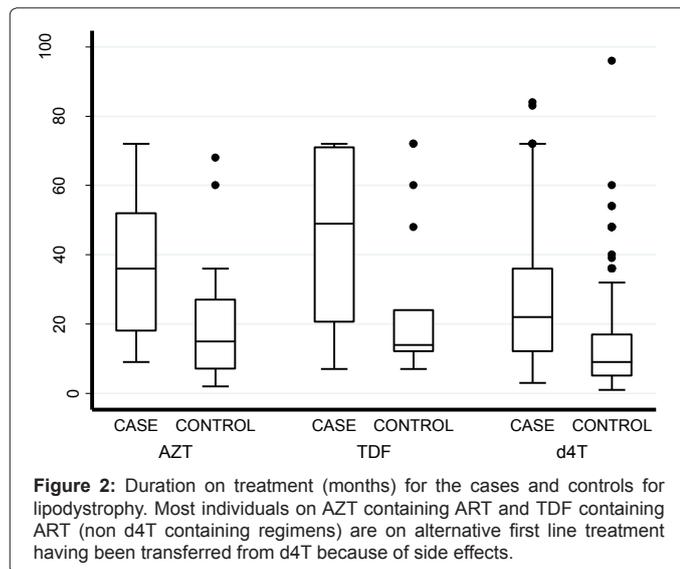
Figures 2 and 3 represent a detailed analysis of lipodystrophy

	Reported ADRs'			
	1	2	3	4
HIV/AIDS treatment (%)	42	30	14	2
HIV/AIDS-TB treatment (%)	45	31	7	0
TB treatment (%)	47	20	7	0

Table 2: Percentage frequency for patients reporting the profiled adverse drug reactions that is CNS, PN, LD and SH.

Treatment		PN		CNS		LD		SH	
		Case	Control	Case	Control	Case	Control	Case	Control
ART	Females; Males	116;35	63;26	54;16	125;45	79;11	100;50	39;12	140;49
	Age (yrs)	40(35,47)	39(33,46)	40(34,47)	40(34,46)	40(36,46)	40(33,47)	39(34,44)	40(34,47)
	Time on Treatment (months)	17(11,36)	15(9,30)	15(9,24)	17(10,36)	27(15,48)	14(9,23)	18(10,32)	16(10,36)
	Weight (kg)	60(52,66)	61(55,67)	61(52,66)	60(54,67)	60(53,68)	60(52,66)	61(54,66)	60(53,67)
	Height (m)	1.63(1.59,1.68)	1.64(1.6,1.69)	1.63(1.6,1.7)	1.63(1.6,1.68)	1.63(1.57,1.66)	1.64(1.6,1.69)	1.63(1.6,1.68)	1.63(1.6,1.69)
	BMI (kg/m ²)	22(20,25)	22(21,24)	22(20,25)	22(20,24)	23(20,25)	22(20,24)	22(20,24)	22(20,25)
ART-TB treatment	Females; Males	35;28	22;13	23;15	34;26	5;1	52;40	10;8	47;33
	Age (yrs)	39(34,47)	35(29,39)	37(31,43)	38(33,44)	43(35,49)	38(32,43)	38(32,42)	38(32,43)
	Time on Treatment (months)	6(4,12)	4(3,16)	4.5(3,12)	7(4,13)	27(12,48)	6(4,9)	6(3,8)	6(4,14)
	Weight (kg)	58(50,68)	55(47,62)	57(53,65)	56(47,65)	62(55,76)	56(47,65)	63(55,72)	55(47,64)
	Height (m)	1.65(1.6,1.72)	1.62(1.57,1.68)	1.65(1.56,1.7)	1.64(1.6,1.69)	1.6(1.57,1.66)	1.64(1.6,1.7)	1.66(1.63,1.74)	1.64(1.58,1.7)
	BMI (kg/m ²)	21(19,24)	20(19,23)	21(19,25)	21(19,23)	24(22,29)	21(19,23)	23(19,26)	21(19,23)
TB treatment	Females; Males	26;29	17;20	16;11	27;38		43;49	10;3	33;46
	Age (yrs)	39(33,50)	35(30,42)	36(30,45)	37(31,49)		37(31,45)	38(33,52)	37(31,45)
	Time on Treatment (months)	3(2,7)	4(2,6)	3(2,7)	4(2,7)		4(2,7)	3(2,6)	4(2,7)
	Weight (kg)	62(55,69)	59(52,64)	60(53,70)	60(54,66)		60(54,66)	63(60,65)	59(53,66)
	Height (m)	1.67(1.61,1.72)	1.68(1.62,1.72)	1.62(1.58,1.69)	1.69(1.64,1.72)		1.68(1.62,1.72)	1.63(1.58,1.7)	1.68(1.62,1.72)
	BMI (kg/m ²)	22(20,25)	21(19,24)	22(20,27)	21(19,24)		22(20,24)	23(21,25)	21(19,24)

Table 3: Summary statistics of adverse drug reactions showing frequencies, median and interquartile range for the independent variables investigated.



Coefficients	Estimate	Estimated Standard Error	P value
Intercept	-2.243956	0.260215	$p < 2e-16$
Time on Treatment	0.050945	0.009764	$p = 1.81e-07$

Table 4: The logistic regression (binomial) model for lipodystrophy incidence against time on stavudine.

where time on treatment was shown to be strongly correlated with development of this ADR. The results in Figure 3 and Table 4 show that the duration on treatment with stavudine correlated with an increase in incidences of lipodystrophy. For those on stavudine, females were found to be more susceptible to lipodystrophy (OR=3.35 (1.55, 7.22); $p=0.0023$) in comparison to males with 36% of females exhibiting this side effect versus 12% of males. Furthermore, females had significant odds of susceptibility to lipodystrophy compared to males for all patients on ART with odds of 4.14 (CI (2.15, 8.01) ($p < 0.0001$)). HIV infected patients with lipodystrophy had a significantly higher mean BMI in comparison to those without (23 kg/m^2 vs. 21 kg/m^2 ; $p < 0.0029$). Duration on ART had an impact on predisposition to lipodystrophy (controls vs. cases) (15 months vs. 33 months, $p < 0.0001$).

Central nervous system ADRs

The patients on an efavirenz containing regimen (ART only)

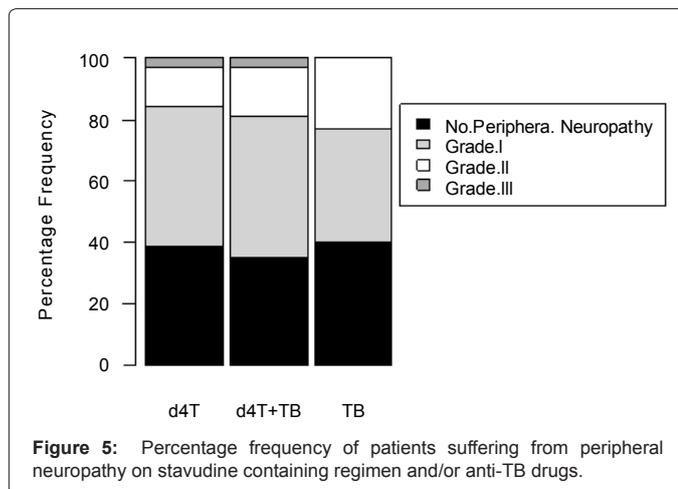
were found to have a higher mean BMI as compared to those on both ART (containing efavirenz) and TB treatment (22.5 kg/m^2 vs. 21.5 kg/m^2 , $p=0.0758$). A statistically significant difference was observed, for duration on ART (containing efavirenz) as compared to ART and TB treatment and those on TB treatment only (median (IQR) months) (14(7,24); 6(4,13); 3.5(2,6.5); $p=0.0001$) respectively.

Figure 4 represents a detailed analysis of central nervous system (CNS) side effects. There was a significant difference in frequencies of CNS side effects for those who were on an efavirenz containing regimen compared to those on a non-efavirenz containing regimen (ART only) (43% vs. 17%, $p < 0.0001$). However, there was no significant difference in the frequencies of CNS side effects between those who were on anti-TB drugs compared to those who were on both ART (containing efavirenz) and anti TB drugs (29% vs. 38%, $p=0.19$) respectively. The same was noted in the frequency differences between those on ART (efavirenz containing regimen) and ART and TB treatment (43% vs. 38%, $p=0.20$). The most prevalent CNS side effect for patients on efavirenz was hallucinations with a frequency of 25% (Figure 4). The patients on TB treatment had sleep problems especially those on the treatment combination of isoniazid, rifampicin, ethambutol and pyrazinamide.

The duration of treatment for patients on RHEZ was found to have been significantly less compared to those who were on RH only (3.6 months vs. 4.8 months; $p=0.034$). Exclusively, TB treatment patients with CNS side effects had significantly higher BMI (23.23 kg/m^2 vs. 21.4 kg/m^2 ; $p=0.046$) compared to those without CNS side effects.

Peripheral neuropathy

In patients and controls for peripheral neuropathy, the duration on ART alone (containing stavudine) as compared to ART (containing stavudine) and TB treatment and those on TB treatment only, showed statistically significant differences, (median (IQR) months) (15(9, 24); 6(4, 12); 3.5(2, 6.5); $p=0.0001$) respectively. Individuals on combined TB treatment and a stavudine containing regimen had a lower mean BMI compared to those on ART (stavudine containing regimen only) (21.5 kg/m^2 vs. 22.6 kg/m^2 , $p=0.0391$). Age showed statistically significant differences for susceptibility to peripheral neuropathy. When the treatment groups were considered independently, a greater susceptibility to peripheral neuropathy was found for those over 40



years for ART only (containing stavudine) (OR=2.4, CI (1.21, 4.74): p=0.018), for ART (containing stavudine) and TB treatment (OR=2.63, CI (0.91, 8.23): p=0.067), and for those on TB treatment only (OR=1.87, CI (0.77, 4.57): p=0.243). Considering all patients on a stavudine containing regimen, age >40yrs was associated with increased risk of peripheral neuropathy (OR=1.91, CI (1.09, 3.34): p=0.032). Figure 5 shows a comparison of PN in the different treatment groups with similar frequencies of grade I and II level PN observed and level III PN observed only in those patients whose treatment included stavudine.

Skin hypersensitivity

Skin hypersensitivity reactions were observed in 14% of patients currently on nevirapine containing HAART. The frequency of 48% reported by patients who had previously been on nevirapine containing HAART is accounted for by patients who were changed from a nevirapine containing ART regimen to one based on efavirenz due to the skin hypersensitivity reaction caused by nevirapine. Females were more susceptible to skin hypersensitivity reactions (OR=4.65, CI (1.07, 27.84): p=0.0329) compared to males, for patients on anti-TB drugs. This gender susceptibility to skin hypersensitivity reactions was not observed in females on HAART.

Discussion

This study has simultaneously evaluated major ADRs associated with the use of ARVs and anti-TB drugs. This approach has allowed us to explore the contributions of various drug combinations on the occurrence and severity of ADRs, thus offering a clinically relevant qualitative and quantitative measure of the burden of ADRs in the treatment of HIV/AIDS, TB and HIV-TB co-infection.

ADRs have been reported to be the 4th leading cause of death in the USA [18] and accounting for 197 000 deaths in Europe annually [19]. The cost of ADRs to the healthcare system is enormous with the USA estimating it at US\$137-177 billion a year [20] and Europe at 79 billion Euros a year [19]. It has been reported that 45% of patients who are started on ART, discontinue or change treatment during the first year, frequently due to poor treatment tolerance and adverse drug reactions [21]. The high incidence of ADRs in patients on ART and anti-TB treatment that we have observed in this study in Zimbabwe is in agreement with reports from others [22] and highlights safety issues in the treatment of HIV/AIDS and/or TB. Our study has shown that peripheral neuropathy is the most common ADR in patients on ART and TB treatment in agreement with the work of others [23]. In

Kenya, an analysis of 1490 suspected ADR reports revealed that 79% of ADRs were related to antiretroviral medicines [24]. The most common ARV-related ADRs observed in that study were lipodystrophy, nausea and vomiting, peripheral neuropathy, pruritus rash, anaemia, erythema multiforme, and maculopapular rash. A survey in the use of ARVs and management of HIV/AIDS in Nigeria reported that 26% of the patients had experienced ADRs to ARVs [25]. This has been supported by recent studies by Eluwa et al, [26] who also showed that ADRs were more likely to be experienced in the first 6 months of treatment. In a South African study involving 665 adults admitted to a hospital in an HIV/AIDS endemic region, 6.3% patients were admitted as a result of an ADR and another 6.3% developed an ADR in hospital [27]. Given this high incidence of ADRs to ART and anti-TB drugs, future studies need to evaluate the cost to the healthcare system with respect to hospital admissions, poor compliance leading to possible drug resistance, and lost working hours due to absenteeism due to ADRs.

Previous studies have shown strong associations of stavudine with lipodystrophy and peripheral neuropathy [22,28-30], efavirenz with CNS [31], isoniazid with peripheral neuropathy [23], and nevirapine with skin hypersensitivity reactions [32,33]. In this study we have seen similar trends but also noted additional drug combination specific ADRs patterns. Consideration of the role of gender and duration of treatment could help clinicians rationalise ADRs they observe in patients.

Similarly to other findings with regards to high incidences of peripheral neuropathy, our results further showed that older age (>40yrs) is a risk factor for peripheral neuropathy, particularly for those on stavudine containing regimens and this agrees with a number of studies [30,34,35]. To quote one comment from a patient experiencing peripheral neuropathy "The discomfort I get with this medication is so severe at times that I don't sleep through the night, I regret taking the medication." From some of the comments given by patients, it is clear that adherence to a treatment regimen might be compromised because of adverse drug reactions.

Our findings on stavudine associated lipodystrophy agree with a number of studies reporting increased susceptibility for women as compared to men [36,37]. Cabrero et al. [38] notes that significantly more women reported lipodystrophy of lower limbs and buttocks as well as lipohypertrophy as compared to men. However they noted no gender differences in the global prevalence of lipodystrophy for patients on HAART. A higher body mass index was associated with development of lipodystrophy during treatment for those on HAART. We also observed that prolonged use of a stavudine containing regimen increases the risk for lipodystrophy in agreement other reports [28,39].

Our results show a significant number of patients have CNS side effects on efavirenz containing ART regimens, efavirenz containing ART regimens + TB treatment and TB treatment only regimens compared to patients on non EFV (43% vs. 17%, p<0.00001). Several studies have proposed the need to reduce the dose of efavirenz [14,40,41] in some patients in order to reduce these adverse drug reactions and successful therapeutic outcomes have been demonstrated for slow metabolisers or those with low clearance of efavirenz [40].

Nevirapine is the most commonly used NNRTI in developing countries because of its lower cost, compared with efavirenz. Nevirapine-induced hypersensitivity rash has been reported to occur in 16%-20% of patients in studies in developed countries [32,42,43]. Our results show 14% of the patients on a nevirapine regimen have this side effect and 48% of the patients on a non-nevirapine regimen,

after having been changed from nevirapine due to skin hypersensitivity. We also observed that females are more susceptible than males to skin hypersensitivity arising from TB medication.

Conclusions

ART is supposed to increase life expectancy and improve the quality of life of HIV/AIDS and TB patients but given the extent of ADRs observed in this study, it appears that the quality of life of most patients is compromised. This has a number of long term implications which include reduced economic productivity of a significant number of people and a new type of stigmatisation associated with the visual appearances clearly associated with ART ADRs.

Our study shows the enormous ADRs burden due to ART and anti-TB treatment which needs further studies to estimate its cost to the healthcare system. The studies also highlight the need to understand what predisposes some people to the ADRs with the objective of finding biomarkers that can be used to guide ART towards safe and efficacious outcomes. There are now an increasing number of reports which indicate that there might be some genetic markers predictive of the occurrence and severity of some of these ADRs.

Using samples collected from these patients, we will conduct pharmacogenomic studies in search of such biomarkers that could assist clinicians in tailor making ART regimens for efficacy and safety.

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