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Original Research

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Relationship Between Treatment Comorbidities and HIV Viral Suppression Among People Living With HIV in Johannesburg

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Abstract

HIV has globally infected over 37.9 million people, of which 28.2 million (73%) are on antiretroviral treatment, and 66% of those on treatment are virally suppressed. In South Africa, however, low rate of viral suppression (47%) among people living with HIV is a major health problem that has continued to fuel HIV prevalence. A cross-sectional quantitative research design was used to investigate the relationship between treatment comorbidities and viral suppression among HIV-infected adults aged 18–49 who were diabetic, had cancer, or tuberculosis in Johannesburg. HIV Care Continuum formed the theoretical framework for this research. An existing HIV-infected patient de-identifiable dataset (n = 602) was used for the descriptive and logistic regression analysis. Results revealed a statistically significant association between tuberculosis treatment and viral suppression—adjusted OR = 1.534, (1.053, 2.234), and p = 0.02—indicating that treatment of comorbidities, such as tuberculosis, has positive impact on viral suppression outcomes.

Results, however, revealed that the model for diabetes treatment and viral suppression—OR = 0.993, (0.658, 1.498), and p = 0.97—and the model for cancer treatment and viral suppression—OR= 1.234, (0.844, 1.805), and p = 0.27—were not statistically significant.

Treatment of comorbidities, such as TB and HIV, positively impacts viral suppression outcomes. These findings suggested that concurrent, simultaneous, or integrated treatment models for comorbidities can help to achieve HIV viral suppression. This study contributes to positive social change by highlighting the effect of treatment comorbidities on viral suppression in people living with HIV (PLWHIV) in an under-resourced

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setting, which could inform policy and influence decisions on HIV care and management.

Keywords: *treatment comorbidities, cancer, diabetes, TB, HIV, viral suppression*

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Introduction

Globally, HIV has infected over 79.3million people since the inception of the pandemic, leaving an estimated 36.3 million dead (Joint United Nations Programme on HIV/AIDS [UNAIDS], 2022). As of June 2021, people living with HIV globally were estimated at 37.9 million, of which 84% were aware of their HIV positive status; more than 28.2 million (73%) were on antiretroviral treatment, also known as ART (Kay et al., 2016; UNAIDS, 2022); and 66% of people on ART were virally suppressed (UNAIDs, 2022). Antiretroviral treatment effectively suppresses viral load and viral transmission (Kay et al., 2016), and viral load suppression reduces HIV transmission and prevalence rates (Kay et al., 2016; UNAIDS, 2016–2021).

In South Africa, insufficient viral suppression (which means there is a detectable level of HIV in the blood of HIV-infected individuals) was estimated to be around 47% compared to 66% of global viral suppression in 2020. This is a major problem in the HIV Care Continuum South Africa (UNAIDS, 2016–2021; UNAIDS, 2022) and has contributed to the high mortality and morbidity of people infected with HIV in South Africa (Ekeji, 2016; Galea et al., 2018; StatsSA, 2018)—especially among those co-treating other health conditions and HIV (Galea et al., 2018; StatsSA, 2018).

Antiretroviral treatment has immensely improved the quality of life, health, and life expectancy of HIV-infected individuals (CDC, 2014). Hence, sustained viral load suppression is necessary to achieve optimal health outcomes (Kay et al., 2016). To achieve a community free of HIV infection requires improvements in the outcomes of every step of the HIV Care Continuum (CDC, 2014).

This study described the relationship between treatment of comorbidities (diabetes, cancer, or TB) and viral suppression among HIV-infected adults aged 18–49 in Johannesburg, South Africa, which has achieved the UNAIDS 2020 first 90% target of increasing awareness of HIV-positive status. The success of the ART program in South Africa has also increased the national life expectancy from 56 years in 2010 to 63 years in 2018 (Avert, 2020). However, the second target (to achieve 90% initiation of antiretroviral therapy in HIV-positive individuals) and the third target (to achieve 90% viral suppression in PLHIV on treatment) are still at 61% and 47% respectively at the time of this study (Lippman et al., 2019; UNAIDS, 2022).

It was not clear, however, if the existence and treatment of comorbidities (such as, diabetes, cancer, or tuberculosis) influenced viral suppression. Hence the primary research question for this study was: does any relationship exist between treatments of comorbidities (such as, diabetes, cancer, or tuberculosis) and viral suppression among HIV-positive adults, aged 18–49, in Johannesburg, South Africa?

This study's purpose was to describe the relationship between the treatment of comorbidities (diabetes, cancer, or TB) and viral suppression among HIV-infected adults aged 18–49 in Johannesburg. HIV infection is still highly prevalent in South Africa (StatsSA, 2018) despite government spending on HIV programs, which in 2017 was estimated to be more than $1.54 billion (about $5 per person in the United States) annually

(Avert, 2020) and organizational and individual efforts to combat the disease. However, low rates of viral suppression have been implicated in high HIV prevalence in South Africa (Avert, 2020).

The independent variable of the study was the treatment of comorbidities (such as diabetes, cancer, or TB), and the dependent variable was viral suppression. Covariates included age, sex, race, and medical aid; currently on heart disease treatment; currently on hypertension treatment; currently on HIV treatment; and retention to HIV care, adherence to treatment, disability, alcohol/drug abuse, highest educational qualification, marital status, and employment status. The findings are positive contributors to social change by informing policy makers on existing gaps in the treatment of co-morbidities and viral suppression, which may warrant the development of better strategies to achieve and maintain viral suppression (Kay et al., 2016).

Theoretical Framework

The HIV Care Continuum (HCC) formed the framework for this research, and the initiative was formed through Executive Order by then U.S. President Barrack Obama through the passage of the Affordable Care Act (ACA), in HIV health care, in the United States in 2013, which was done to prioritize the establishment of national indicators for HIV care (CDC, 2014). The HCC is a public health model, which consists of five steps such as (1) infection diagnosis; (2) linkage to HIV care; (3) receipt of HIV care; (4) retention to care; and (5) achievement and maintenance of viral suppression, which people with HIV go through from diagnosis to achieving and maintaining viral load suppression (Kay et al., 2016).

The HIV Care Continuum (HCC) was an appropriate framework for this research because this model is useful at the individual level as a tool to assess care outcomes, as well as at the population level to analyze the proportion of community members with HIV who are in any of the successive steps. I used the HCC to answer research questions on the relationship between the treatment of comorbidities and viral load suppression of HIV infections in Johannesburg. This is because HIV-infected patients, who were diagnosed with health conditions (such as, diabetes, cancer, or TB), are most likely to be linked to care, retain in care, adhere to ART, and achieve viral suppression (Kay et al., 2016). This framework is used by care providers and policymakers to identify areas of gaps in services, and to develop informed strategies to support patients to meet treatment outcomes (Kay et al., 2016).

HCC is a framework developed to achieve the optimal goal of viral suppression to an undetectable level in the blood of people living with HIV (Centers for Disease Control and Prevention [CDC], 2019), as well as highlight the dynamic stages of HIV care (Kay et al., 2016). The HCC framework is also used to identify weak points in HIV care, interventions, strategies, and policies to shape the continuum. The CDC (2019) also described five steps of the HIV Care Continuum to include: (a) diagnosed (individual received a diagnosis of HIV); (b) linked to care (HIV-positive individual visited HIV health-care provider within 30 days after HIV diagnosis); (c) received care (HIV-infected person was given care); (d) retained to care (PLWHIV—people living with HIV—was retained to care); and (e) viral suppression (amount or level of HIV in the blood of HIV-infected person is undetectable or incredibly low). The findings of this study positively influence health-care decisions relating to the health conditions and treatment of South Africans who need to co-treat other infections and HIV.

Literature Review

In this study, the effect of the treatment of comorbidities on viral suppression in HIV patients in an under-resourced setting was examined. The gap in the public health literature on the relationship between the treatment of comorbidities and viral suppression in HIV patients in Johannesburg, South Africa, was also

addressed. The findings of this study positively influence health-care decisions relating to the health conditions of South Africans who need to co-treat other infections and HIV.

Diabetes and HIV

In the United States of America, patients with HIV received poorer care for their coexisting conditions than did those without HIV (UNAIDs, 2022). HIV-infected individuals with cardiometabolic conditions were less likely to progress in the stages of care compared to patients without co-infection (Chang et al., 2019). A study by Chang et al (2019) reported that diabetes was not associated with progression in care, unlike patients with hypertension comorbidity that had greater progression in care.

In Kenya, HIV-infected individuals with diabetes condition were treated for HIV rather than diabetes; due to the availability of AIDS funding and the policy of out-of-pocket payment for diabetes, and this practice has severely affected comorbid treatment outcomes (Bosire et al., 2018). Diabetes has been described as a chronic disease that manifests when the body of an individual cannot effectively use the insulin it produces (Bosire et al., 2019; Kay et al., 2016). Diabetes is a fasting blood glucose level of greater than 126 mg, meaning 8 hours without food before a blood specimen was collected for testing; a blood glucose level of 00 mg after eating or self-reported ongoing diabetes treatment (Kay et al., 2016). In this study, patients' diabetes, cancer, and TB status were ascertained from the treatment records.

Cancer and HIV

Cancer is a disease caused when cells divide uncontrollably and spread in surrounding tissue. It is a genetic disease, caused by changes in a person's genes. Human cells undergo a process of cell division, a process where cells grow and multiply to form new cells, as needed, by the body (National Cancer Institute, n.d.). Hence, when cells are damaged or become old and die, new cells replace them.

However, sometimes this orderly cell division process can break down, causing abnormal cells to grow and multiply where they are not supposed to. This cell starts by forming tumors, which are lumps of tissues, that can either be cancerous or not. Non-cancerous tumors do not spread to other tissue, whereas cancerous tumors, also known as malignant tumors, invade other tissues to form new tumors (a process called metastasis). Most cancers form solid tumors, except leukemias, which are cancers of the blood (National Cancer Institute, n.d.).

Among PLWHIV, cancers, such as Kaposi Sarcoma (cervical cancer), non-Hodgkin lymphoma, conjunctival cancer, vulva, and human papilloma virus (HPV), show association compared to HIV-negative counterparts, and the linkage is on the bases of co-infections with oncogenic viruses and poor access to HIV care (Dhokotera et al., 2019). Conversely, people living with HIV are at low risk of cancers, such as breast, prostate, and colon, inferring that not all types of cancer are related to immune suppression (Dhokotera et al., 2019).

Tuberculosis and HIV

In a study by Ayah (2018), tuberculosis (TB) was one of the most common comorbidities associated with an elevated level of loss to follow-up and early mortality among people living with HIV/AIDS. South Africa is one of the countries in the world with the highest HIV burden, in 2017, with 78,000 related deaths of complications of comorbid treatment and management of TB and HIV (Myburgh et al., 2020). The non-adherence to concurrent treatment is more likely to be among patients with extra pulmonary TB and undisclosed HIV status (Mazinyo et al., 2016). Patients co-infected with TB and HIV were more likely to adhere to TB treatment compared to antiretroviral treatment (Mazinyo et al., 2016).

In South Africa, treatment of co-morbidities, such as TB and HIV, has been part of government health policies. It is government policy to test every TB new patient for HIV in the Gauteng Province (Gauteng

Department of Health, 2020). However, literature on the association between treatments of comorbidities, such as TB and viral suppression among adults aged 15–49 in Johannesburg, is limited; hence this study has filled that gap.

Viral Suppression

Sustained viral suppression effectively prevents the transmission of HIV from an infected person to uninfected individuals (UNAIDs, 2022). In the United States, out of 86% of people diagnosed with HIV infection in 2016, only approximately 30% achieved viral suppression (Kay et al., 2016). Similarly, of the 90% of people who know their HIV-positive status in South Africa, only 47% had achieved viral suppression in 2019 (UNAIDs, 2022). Centers for Disease Control and Prevention (2014) suggested that improvement in just one step of the HIV Care Continuum would make a difference in the goal of achieving viral suppression. Importantly, people living with HIV who were diagnosed, linked to care, retained in care, and adhered to treatment had the highest rate of achieving viral suppression (Cabral et al., 2018; CDC, 2019; Gómez-Olivé et al., 2013).

Research Questions and Hypotheses for the Study

1. Research Question 1 (RQ1): Is there a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with diabetes in Johannesburg?

   Null Hypothesis1 (H01): There is no relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with diabetes in Johannesburg.

   Alternative Hypothesis1 (Ha1): There is a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with diabetes in Johannesburg.

2. Research Question 2 (RQ2): Is there a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with cancer in Johannesburg?

   Null Hypothesis 2 (H02): There is no relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with cancer in Johannesburg.

   Alternative Hypothesis2 (Ha2): There is a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with cancer in Johannesburg.

3. Research Question 3 (RQ3): Is there a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with TB in Johannesburg?

   Null Hypothesis3 (H03): There is no relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with TB in Johannesburg.

   Alternative Hypothesis3 (Ha3): There is a relationship between treatment of comorbidities and viral load suppression among HIV-infected adults aged 18–49 with TB in Johannesburg.

Methods

The study included HIV-positive adults, aged between 18 and 49, with diabetes, cancer, or TB in Johannesburg. The study participants are defined as adult men (n = 179) and women (n = 423), within the age range of 18–49, who were co-treating health conditions, such as cancer, diabetes, or TB and HIV in the

Johannesburg Gauteng Province. A de-identifiable secondary dataset was used, following permission from the Human Sciences Research Council (HSRC) that originally collected the dataset.

The chosen study population was considered particularly important for this study because there was a gap in the literature on this topic in this population. Importantly, this age group had the highest HIV prevalence in the chosen population (StatsSA, 2018), with Gauteng (Johannesburg) being second to last virally suppressed province in South Africa (Cabral et al., 2018). De-identifiable data set was used for ethical reasons (Ayah, 2018).

Data Sources

In this study, an existing patient's de-identifiable electronic record from the Human Sciences Research Council (HSRC) (HSRC, 2017) was analyzed. This was the fifth household national level repeat survey of the HSRC of 2017, which included every member of the selected household. The HSRC survey was purposed to determine the viral load (VL) in HIV-positive individuals and to estimate the proportion of persons receiving antiretroviral therapy who were virally suppressed (HSRC, 2017).

The data collection was done longitudinally from 2016–2018. Data were collected through clinical measurements, face-to-face interviews, and focus-group observation from the South African population. Digital electronic tablets were used for questionnaires, and dried blood spot (DBS) samples were used to collect blood samples for biomarker testing.

The survey was funded by the Bill and Melinda Gates Foundation, the CDC, the Human Sciences Research Council, the President's Emergency Plan for AIDS Relief (Emergency Plan), the South African National AIDS Council, and the United Nations Children's Fund (HSRC, 2017).

Permission for dataset access was secured, and the dataset was downloaded as directed, respecting—and observing—all confidentiality, ethical rules, and protocols to maintain confidentiality throughout the study. The focus was on the variables of interest, such as patient HIV positive status, being on diabetes medication, cancer medication, and TB medication, and patient's viral suppression. Viral suppression was the dependent variable in this study, where patients with viral load test result of less than 200 copies/ml on the most recent test (2017) were regarded as being virally suppressed. Patients with the viral suppression test result of more than 200 copies/ml on the most recent (2017) test were regarded as being virally unsuppressed.

Measures

This research included multiple dichotomous variables, such as being treated for diabetes (yes = 1) or not treated for diabetes (no = 0); being treated for cancer (yes = 1) or not being treated for cancer (no = 0); being treated for TB (yes = 1) or not being treated for TB (no = 0); virally suppressed (yes = 1) or virally not suppressed (no = 0).

The operationalization of the independent variables was defined as being treated (yes = 1) or not being treated (no = 0) for diabetes, cancer, or TB, known as dichotomous variables (Laureate Education, 2017; Osborne, 2015; Warner, 2013). We planned that the operationalization of the dependent variable would be VL less than 200 copies/ml on the most recent test in 2017 to be virally suppressed (1) or not virally suppressed (0) when the VL is more than 200 copies/ml on the most recent test in 2017. The odds ratio was utilized as a measure of association.

Logistic regression assumes that the observations are independent; however, this assumption was handled by careful sampling (Warner, 2013). Another assumption of logistic regression is that the natural log of the odds

ratio and the measurement variables have a linear relationship, although it is difficult to observe when this assumption is violated (Frankfort-Nachmias et al., 2018). However, this was handled using data transformation.

Results

In this study, a descriptive statistical analysis and logistic regression analysis were conducted utilizing the *Statistical Package for the Social Science* (SPSS), Version 25 software (IBM, 2020) to answer the research questions and hypotheses.

Table 1. *Descriptive Statistics Showing Frequencies, Percentages, and Viral Suppression of the Study Dependent and Independent Variables*

Study Variables	Frequency	Valid Percent	Viral Suppression	
			Unsuppressed	Suppressed
Viral load suppression	210	34.9	210 (34.9%)	392 (65.1%)
	392	65.1		
Total	602	100.0		
Currently on diabetes treatment	133	23.5	46(23.7%)	87 (23.4%)
No	432	76.5	148(76.3%)	284 (76.5%)
Yes	565	100.0	194	371
Total	37			
System Missing	602			
Total				
Currently on cancer treatment	174	33.1	66 (36.3%)	108 (31.4%)
No	352	66.9	116 (63.7%)	236 (68.6%)
Yes	526	100.0	182	344
Total	76			
System Missing	602			
Total				
Currently on TB treatment	414	68.8	157 (74.8)	257 (65.6%)
No	188	31.2	53 (25.2%)	135 (34.4%)
Yes	602	100.0	210	392
Total				

In this study, the result of the descriptive analysis suggested that (n = 392) 65.1% of the study population (n = 602) were virally suppressed, whereas (n = 210) 34.9% were virally unsuppressed. In the variable sex, females were 72.4% virally suppressed compared to their male counterparts who had 27.6% viral suppression. Based

on the dataset used in this study, age was only one group (18–49 years). Hence, there were no different age brackets.

Table 2. *Final Logistic Regression Model Showing the Adjusted Odds Ratio (Adjusted With Medical Bills Paid by Medical Aids, Hence Associated With the Outcome) Relating Diabetes Treatment and Viral Suppression Among HIV-Infected Adults in Johannesburg*

Study Variables	Unadjusted Odds Ratio	95% *CI* Lower	95% *CI* Upper	Sig.	Adjusted *OR***	95% *CI* for EXP(B) Lower	95% *CI* for EXP(B) Upper	Sig.
Currently taking diabetes medication	1.015	0.674	1.527	.94	.993	.658	1.498	0.97
Medical bills paid by medical aid	1.789	1.082	2.957	**.02***	1.757	1.042	2.964	**0.03***

*Assessment of single risk factor but adjusted for confounder (medical bill payment by medical aid).

The adjusted odds with the covariate variable medical bills paid by medical aid was *OR* = 0.993, (0.658, 1.498), and *p* = 0.97 (*p*>0.05). This means that the odds of viral suppression were 0.918 among diabetes patients currently on treatment, but the association was not statistically significant. The lower confidence interval (*CI*) was less than 1 and the upper (higher) *CI* was higher than 1, which also confirms that the association was not statistically significant. The covariate variable that was used in adjusting the odds ratio was medical bills paid by medical aid unadjusted was *OR* = 1.789 (1.082, 2.957), an adjusted *OR* = 1.762 (1.042, 2.980), with the *p* = .03 and *p* = .02 respectively.

Table 3. *Final Logistic Regression Model Showing the Adjusted Odds Ratio (Adjusted With Medical Bills Paid by Medical Aids, Hence Associated With the Outcome) Relating Cancer Treatment and Viral Suppression Among HIV-Infected Adults in Johannesburg*

Study Variables	Unadjusted Odds Ratio	95% *CI* Lower	95% *CI* Upper	Sig.	Adjusted *OR***	95% *CI* for EXP(B) Lower	95% *CI* for EXP(B) Upper	Sig.
Currently taking cancer medication	1.243	.852	1.815	.25	1.234	.844	1.805	0.27
Medical bills paid by medical aid	1.789	1.082	2.957	**.02***	1.703	.993	2.923	**.05***

*Assessment of single risk factor but adjusted for confounder (medical bill payment by medical Aid).

The adjusted odds for cancer treatment and viral suppression was *OR* = 1.234, (0.844, 1.805), adjusted *p* = value (*p* = 0.27), and *p*>0.05. It means that cancer patients who were on treatment had the *OR* = 1.234 of being virally suppressed than that of cancer patients who were not on cancer treatment. However, the association was not statistically significant because *OR* was 1.2, *CI* spans 1, and the *p*-value was *p*>0.05.

Table 4. *Final Logistic Regression Model Showing the Adjusted Odds Ratio (Adjusted With Medical Bills Paid by Medical Aids, Hence Associated With the Outcome) Relating TB Treatment and Viral Suppression Among HIV-Infected Adults in Johannesburg*

Study Variables	Unadjusted Odds Ratio	95% *CI* Lower	95% *CI* Upper	Sig.	Adjusted *OR***	95% *CI* for EXP (B) Lower	95% *CI* for EXP (B) Upper	Sig.
Currently taking TB medication	1.556	1.070	2.263	**.02***	1.534	1.053	2.234	**.02***
Medical bills paid by medical aid	1.789	1.082	2.957	**.02***	1.751	1.057	2.902	**.03***

*Assessment of single risk factor but adjusted for confounder (medical bill payment by medical Aid).

Logistic regression was conducted to answer Research Question 3 (RQ3), which was to determine the relationship between treatment of comorbidities (TB) and viral suppression among HIV-infected adults, aged 18–49, in Johannesburg and adjusting the odds with medical bills paid by medical aids for the final model. The results revealed the adjusted *OR* = 1.534, (1.053, 2.234), and $p = 0.02$. This means that the odds of viral suppression were 1.534 among TB patients currently on treatment, and the association was statistically significant. TB patients who were currently on TB treatment, at the time data for this study was collected, had increased odds of *OR* = 1.5 viral suppression compared to TB patients who were not on TB treatment.

Medical bills paid by medical aids had unadjusted *OR* = 1.789, (1.082, 2.957), $p = 0.02$ ($p < 0.05$). This result was statistically significant and revealed a strong association between TB treatment and viral suppression.

Discussion

In this study, the authors determined that treatment of comorbidities and viral suppression among adults, aged 18–49, who had diabetes in Johannesburg were statistically not significant. This result is in line with the finding of Chang et al. (2019) who explained that diabetes was not associated with progression in care, unlike patients with hypertension comorbidity, who had greater progression in care. However, this result extends knowledge in the field of public health on the topic studied.

This study showed a statistically significant association between treatment of comorbidities, such as TB and viral suppression, among HIV-infected adults aged 18–49 in Johannesburg. The association was observed both in the crude and adjusted odds ratio. This indicated that HIV-infected adults who were currently co-treating TB and HIV had a higher odds ratio (*OR*) of being virally suppressed.

These findings align with the theory of HCC, whereas the theory's construct of treatment and viral suppression specifically explains and supports these findings (CDC, 2014; Kay et al., 2016). In the study by Mazinyo et al. (2016), patients co-infected with TB and HIV were more likely to adhere to TB treatment compared to antiretroviral treatment.

Limitations

HIV prevalence in South Africa crosses across all ages and provinces, but this study focused only on adults aged between 18–49 who co-treated other chronic diseases and health conditions, such as diabetes, cancer, or TB with HIV. These parameters could limit the generalization of the results of this study; however, the ages of 18–49 represented the highest number of people infected with HIV in South Africa (StatsSA, 2018), which is in line with findings of other researchers conducted in other countries of the world (UNAIDS, 2016–2021).

This study was limited to only HIV patients with health conditions, such as diabetes, cancer, or TB, whereas HIV-infected patients may have co-treated other health conditions other than the above mentioned three predictive health conditions. This may have affected the generalization of the results.

This study included all HIV-infected patients receiving treatment for diabetes, cancer, or TB without specifying the type of treatment or drug a patient was using for a specific health condition. This may have affected the internal and external validity (findings) of the study.

This study included all males and females in the age bracket selected for this study. However, the age of the study respondents, which was proposed to be used as a covariate in this study, had only one value in the secondary dataset (15–49 = 1) used for analysis. There was no grouping of the age brackets within this age based on the dataset; therefore, age was not incorporated in the study final model.

Sex was also proposed as a confounder in this study; however, it was not included in the regression final model. Hence, it was statistically insignificant, although previous studies showed that women are most likely to adhere to treatment than their male counterparts.

Conclusion

Null Hypothesis 3 (H03) was rejected since there was no relationship between treatment of comorbidities and viral suppression among HIV-infected adults aged 18–49 who had TB in Johannesburg.

Null Hypothesis 1 (H01) of three stated there was no relationship between treatment of comorbidities and viral suppression among HIV infected adults aged 18–49 who had diabetes in Johannesburg.

Null Hypothesis2 (H02) stated that there was no relationship retained between treatment of comorbidities and viral suppression among HIV infected adults aged 18–49 who had cancer in Johannesburg.

The authors concluded that the treatment of comorbidities, such as TB, positively impacts viral suppression outcomes. This study finds that an integrated treatment model of comorbidities, among HIV-infected persons in the communities, helps to achieve viral suppression. It was also found that treatment of the whole person reduces HIV prevalence and supports the attainment of an HIV-free society.

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