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# Addressing Cardiometabolic Challenges in HIV: Insights, Impact, and Best Practices for Optimal Management—A Narrative Review

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## ABSTRACT

**Introduction:** Since the advent of highly active antiretroviral therapy (HAART), morbidity and mortality rates associated with human immunodeficiency virus (HIV) have significantly decreased leading to prolonged life span of Individuals living with HIV due to the effectiveness of antiretroviral therapy. However, this prolonged lifespan alone does not fully account for the increased incidence of cardiometabolic complications. These complications result from a complex interplay of factors such as chronic inflammation, immune activation, ART-related metabolic effects, and lifestyle changes. which contribute to elevated morbidity and mortality rates, therefore requiring a deeper understanding and setting effective management strategies. This review aims at providing insights and a nuanced understanding of the relationship between HIV and cardiometabolic disorders, explore their clinical implications and adapt optimal management strategies to address the multifaceted challenges at the intersection of HIV and cardiometabolic health, ultimately enhancing patient outcomes and quality of life.

**Methods:** Data retrieval was conducted using a predetermined search strategy from medical journals that were published in bibliographical databases like PubMed, Science Direct and Embase. This review systematically considered and synthesized current literature on the association between cardiometabolic challenges and HIV.

**Results:** This review provides a detailed exploration of the interrelationship between HIV and cardiometabolic challenges, with an emphasis on insights, impact, and best practices for optimal management. It underscores the high risk of cardiovascular disease, insulin resistance, dyslipidemia, and lipodystrophy in people living with HIV. Recommendations include evidence-based approaches such as routine cardiometabolic risk. Prevention, screening, management, lifestyle interventions (diet and exercise), and optimizing ART regimens to reduce the negative health outcomes experienced by people living with HIV and to direct clinical practice. To reduce health issues, enhance clinical results, and improve the long-term quality of life for people

**Abbreviations:** AIDS, acquired immunodeficiency syndrome.; ART, anti-retroviral therapy; ATV, atazanavir; BMI, body mass index; C, cobicistat; CMDs, cardiometabolic diseases; CMetS, cardiometabolic syndrome; CRP, C-reactive protein; CVDs, cardiovascular diseases; DM, diabetes mellitus; DRV, darunavir; DTG, dolutegravir; EACS, European AIDS Clinical Society; FTC, emtricitabine; HAART, highly active antiretroviral therapy; HDL, high-density lipoprotein cholesterol; HIV, human immunodeficiency virus; IL-VI, interleukin VI; INSTIs, integrase strand transfer inhibitors; INSTIs, integrase strand transfer inhibitors; MACS, multicenter AIDS cohort study; NNRTIs, non-nucleoside reverse transcriptase inhibitors; NRTIs, nucleotide RT inhibitors; PIs, protease inhibitors; PLHIV, people living with HIV.; R, ritonavir; RAL, raltegravir; SG, sleeve gastrectomy; TAF, tenofovir alafenamide; TAGs, triacylglycerols; TC, total cholesterol; TFs, tissue factors; TG, total gestational glucose; TLR2, Toll-like receptor 2; TLR7-9, Toll-like receptors 7-9; VL, viral load.

living with HIV, it is important to early identify cardiovascular risk factors and to follow customized prevention and management methods.

**Conclusion:** This review shows that early detection through regular screening is pivotal through collaboration between healthcare providers, researchers, and policymakers which will allow for timely interventions and drive innovation and address evolving challenges to enhancing the quality of life for individuals living with HIV. Continuing to do research and advocacy efforts, will not only advance knowledge but also optimize the long-term health outcomes for people living with HIV.

## 1 | Introduction

Since the emergence of Highly Active Antiretroviral Therapy (HAART) [1], morbidity rates and death rates associated with human immunodeficiency virus (HIV) have considerably decreased, and as a result, HAART has increased the life expectancy of HIV-positive individuals [2]. Lifestyle-related comorbidities such as diabetes mellitus (DM), hyperlipidemia, and cardiovascular diseases (CVDs) started to surface as a problem and complicate HIV therapy as HIV-infected patients' life expectancies rose [3]. There are several established indicators of risk for cardiometabolic syndrome (CMetS) that are present in individuals infected with HIV/AIDS [2]. Even when the infection with HIV is effectively managed with HAART, the risk of cardiac events, strokes, and other CVDs is twice as high as in the noninfected population [4].

Particularly after the introduction of HAART, certain risk factors are thought to have played a substantial role in the creation of cardiometabolic syndrome in HIV-positive individuals [5]. Higher lipogenesis (irrespective of HAART) [6], increased monocytes [7], inflammation, aberrant blood coagulation, tissue factors (TFs) [8], interleukin VI (IL-VI), and D-dimer [9] are among the theories that have been put out. The use of HIV protease inhibitors (PIs) and non-nucleoside reverse transcriptase inhibitors (NNRTIs) has been linked to a rise in plasma concentrations of total cholesterol (TC) and total gestational glucose (TG), regardless of CD4-positive T-cell counts and HIV viral load (VL). This is particularly concerning.

Cardiovascular illness has been associated with HIV-positive patients at greater rates than in noninfected people, even when conventional risk factors are weighted. Some inhibitors of protease and abacavir are among the antiretroviral drugs that may be hazardous, contributing to this increased risk [8]. ART might be cardioprotective overall, according to new research, which also suggests that unchecked HIV replication is linked to cardiovascular disease. This finding has prompted advocates for quicker ART in patients who are predisposed to coronary artery disease [10].

While a significant portion of the elevated risk of coronary artery disease in HIV-positive individuals is attributed to metabolic abnormalities, it can be difficult to isolate the relative contributions of several other factors, including immunodeficiency, viremia, antiretroviral drugs, and aberrant immunological activation [11]. Observing HIV elite controllers of the infected population who persistently have undetectable plasma viral levels in the absence of antiretroviral therapy is one strategy [12]. It has been hypothesized that variables apart from ART, observable viremia, or immunodeficiency might contribute to excessive risk for cardiovascular disease in infected patients. HIV-related factors, like increased immune responses and inflammatory processes, may have a significant impact [13], as evidenced by findings that elite controllers exhibit atherosclerosis at higher levels compared to HIV-negative patients [12]. This theory aligns well with the increasing understanding that aberrant metabolism and persistent inflammation have a substantial effect in the atherosclerotic plaque formation in people negative for HIV [9]. This review aims at providing insights and a nuanced understanding of the relationship between HIV and cardiometabolic disorders, explore their clinical implications, and adapt optimal management strategies to address the multifaceted challenges at the intersection of HIV and cardiometabolic health, ultimately enhancing patient outcomes and quality of life.

## 2 | Methods

Data retrieval was conducted using a predetermined search strategy from medical journals that were published in bibliographical databases like PubMed, Science Direct and Embase to identify relevant studies examining the association between HIV and cardiometabolic challenges. This review systematically considered and synthesized current literature on the association between cardiometabolic challenges and HIV. Inclusion criteria were established to ensure the relevance and quality of the selected studies. Peer-reviewed studies focusing on human subjects and addressing cardiometabolic risks or complications in individuals living with HIV and published in English from 2000 to the present were included. Non-peer-reviewed articles, case reports, and studies that are non-HIV-specific cardiometabolic research were excluded. Findings were synthesized narratively to highlight the underlying mechanisms, clinical implications, and evidence-based strategies for the prevention and management of cardiometabolic disorders in people living with HIV.

## 3 | Results

### 3.1 | Prevalence and Incidence Rates of Cardiometabolic Conditions in HIV Patients

A Multicenter AIDS Cohort Study (MACS) revealed a correlation between HIV infection and changes in TC, high-density lipoproteins (HDL), and low-density lipoproteins (LDL) [14]. The risk of developing CMETS is age-related, according to the European AIDS Clinical Society's (EACS) guidelines on “the early detection and treatment of metabolic diseases in HIV”,

where the majority of participants in our gathered information were male (54.6%), with a mean age of 42 years [15]. Compared to a survey conducted in Ethiopia by Woldu et al., wherein the median age remained 34 years, this was a marginally higher number [16]. The highest prevalence was observed in older adults aged 40–49 years, individuals with a Body Mass Index (BMI) $\geq 25\,kg/m^2$, and those on long-term antiretroviral therapy (ART) regimens exceeding 5 years. These findings suggest that age, weight gain during ART, and prolonged exposure to ART are significant risk factors for cardiometabolic complications. Conversely, younger individuals aged 20–29 years and those with a normal BMI ($< 25\,kg/m^2$) showed the lowest prevalence, likely due to shorter ART exposure and fewer cumulative risk factors. The study highlights the importance of targeted screening and management strategies, particularly for high-risk subgroups such as older adults and patients with prolonged ART exposure, to reduce the burden of metabolic complications in this population.

The yearly rate of myocardial infarction was found to be 5.1/1000 ($p < 0.001$) as reported by Barbaro [4]. According to Varriale et al. findings, during their study, 29 (4%) of the recruited HIV-positive individuals experienced acute MI. These findings highlight the elevated risk of cardiovascular events in PLHIV, which can be attributed to chronic inflammation, immune activation, and potential adverse effects of antiretroviral therapy (ART). The increased prevalence of MI among PLHIV necessitates targeted strategies for early detection and management of cardiovascular risk factors [5].

Metabolic syndrome (MetS), on the other hand, is strongly linked to a greater HIV viral load and lower CD4 cell numbers, as noted by Carter et al. [17]. Additionally, Grady et al. identified that a low CD4 count ($< 200\,cells/\mu L$) as a risk factor for both dysglycemia and Lactate dehydrogenase (LD) development [18]. Furthermore, HIV-related factors such as a high viral load and low CD4 count significantly increased the risk of end-stage renal disease, with this risk being further exacerbated by coexisting conditions like hepatitis C, diabetes, hypertension, and cardiovascular disease [19].

### 3.2 | Mechanisms Underlying Cardiometabolic Complications in HIV

HIV infection can occur via two major variants HIV-1 and HIV-2. The transmission of HIV-1 subtypes predominated worldwide [20]. Although the data on HIV-2 infection are limited, HIV-2 infections were noticeable in western and central Africa with lower rates compared to HIV-1. While the distinction between these variants is clinically significant, their contributions to cardiometabolic complications require further investigation, particularly regarding their differential effects on inflammatory markers and metabolic pathways [21, 22]. The infection starts with a transmitted founder virus through mucosal membranes. The glycoprotein (gp)120 protein of the viral envelope recognizes CD4 molecules of different white blood cells where this recognition generates structural changes in the gp120 protein to bind chemokine receptors such as CCR5 and CXR4 on the cell surface; then, gp41 aids in the fusion of the viral envelope with the target cell membrane [20, 23]. After that, the viral core enters the infected cell cytoplasm, and the reverse transcriptase converts the viral RNA into DNA, which can be added to the cell genetic material by an enzyme, the integrase. The viral cycle ends with the formation of new viral proteins for the budding of a new viral generation [23].

While this replication process underlies HIV's systemic effects, it also initiates chronic immune activation and inflammation, which are central to the pathogenesis of cardiometabolic complications. Anti-retroviral medications target the different steps of the viral cycle, where CCR5 antagonists inhibit binding with gp120, and fusion inhibitors act on gp41 [24]. The nucleoside and nucleotide or the non-nucleoside reverse transcriptase inhibitors (NRTIs) and (NNRTIs) inhibit reverse transcriptase [24], and other medications act on integrase enzymes, and protease inhibitors interfere with the post-translational processes [24]. By effectively suppressing viral replication, ART reduces chronic inflammation and immune activation, thereby lowering cardiovascular risk in people living with HIV. However, certain ART drugs, particularly protease inhibitors and NRTIs, have been linked to adverse effects such as dyslipidemia, insulin resistance, and lipodystrophy. These side effects can exacerbate cardiometabolic risk factors and potentially negate the cardiovascular benefits of viral suppression. People living with HIV face increased cardiovascular risk due to chronic inflammatory changes and the dysregulation of innate and adaptive immunity, hence, resulting in atherosclerotic changes and eventually developing into various morbidities of cardiovascular diseases. For example, the persistent immune activation results in elevated levels of pro-inflammatory cytokines, such as tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and D-dimer, which contribute to vascular damage and insulin resistance [25].

One of the marks of HIV infection is the depletion of CD4+ cell count over time, even though, HIV-1 free single-stranded RNA can attach to Toll-like receptors 7-9 (TLR7-9) in dendritic cells and plasmacytoid. P17, p24, and gp41 activate the NFκB pathway via Toll-like receptor 2 (TLR2) [20]. This process ends with Tumor necrosis factor α, interleukin-6, D-dimer, C-reactive protein (CRP) production, and residual inflammation. This chronic inflammation increased the overall mortality and morbidity of HIV-infected patients. This microbial translocation further fuels chronic inflammation and accelerates metabolic dysregulation, exacerbating cardiovascular risk in HIV-infected individuals [20, 26]. The depletion of the CD4+ cells in the gastrointestinal tract lymphoid tissues and the destruction of the intestinal mucosal lead to the translocation of microbial content and lipopolysaccharides into the bloodstream and fueling chronic systemic inflammation [26]. According to Lv et al., HIV can infect regulatory T-cells which can end with chronic inflammatory status and increase the risk of atherosclerosis [26].

This microbial translocation and chronic inflammation are central drivers of metabolic syndrome and cardiometabolic diseases in HIV patients. Elevated inflammatory markers disrupt lipid metabolism, contribute to insulin resistance, and impair endothelial function, collectively exacerbating cardiovascular risk. Additionally, Adipokine irregularity in HIV-infected patients was reported [27]. Adiponectin is an anti-

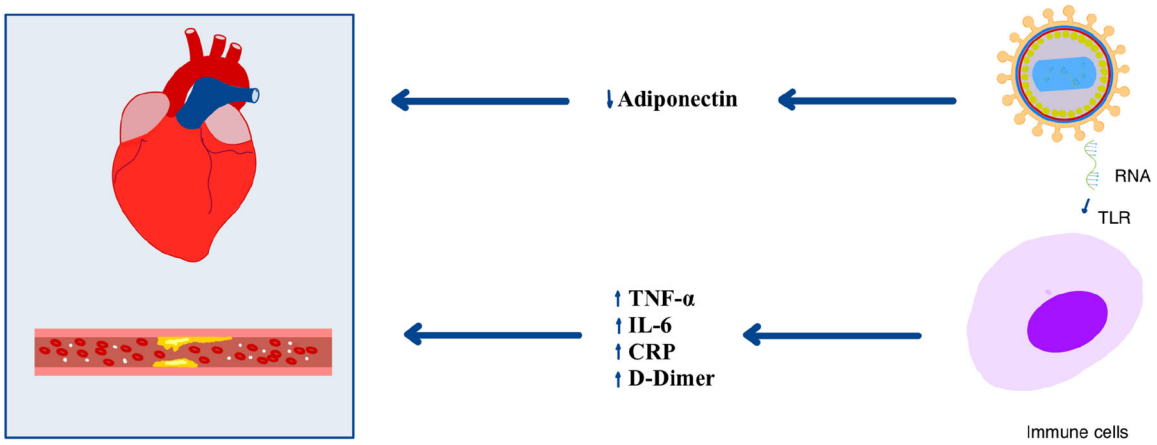


**FIGURE 1** | The pathogensis of cardiometabolic changes in HIV patients.

atherosclerotic hormone released by adipocytes, where the level of adiponectin was decreased in HIV-infected patients and patients on anti-retroviral therapy [27]. Additionally, AIDS-related cardiomyopathy can lead to heart failure characterized by a reduced ejection fraction. Moreover, fibrosis can increase the risk of heart failure with preserved ejection fraction [25]. These findings underscore the complex interplay between HIV-related mechanisms, chronic inflammation, and the potential metabolic effects of ART, necessitating comprehensive approaches to minimize cardiometabolic risks in this population (see Figure 1).

### 3.3 | Effects of Cardiometabolic Complications on HIV Disease Progression and Treatment Outcome

Several studies have found an association between the presence of metabolic syndrome, low CD4 count, and elevated viral load in people living with HIV (PLHIV). While HIV infection relatively predisposes to cardiovascular events, which can nearly double with of anti-retroviral therapy [9].

The administration of anti-retroviral therapy heightens the susceptibility to insulin resistance, diabetes, lipid profile abnormalities, and other metabolic disturbances, posing challenges, particularly in individuals with cardiac or endocrine conditions; hence, a judicious approach to anti-retroviral medications usage is imperative for patients at risk. Routine diabetes screening is essential upon initiation of ART and during therapy to monitor for these complications [28]. Furthermore, in a study conducted by Quin [28], the presence of comorbidities can put an extra burden in people living with HIV, and can generate some psychological impact, and could result in some psychiatric conditions such as depression, which can further complicate disease management.

It is important to consider the psychosocial impact of managing both HIV and comorbidities, as this can affect treatment adherence and overall well-being [28]. in addition to the metabolic disturbance caused by ART, the presence of central obesity, decreased muscle mass, and HIV infection increase the 5-year risk of death compared to the general population [29]. Central obesity, characterized by an excess accumulation of visceral fat, has been shown to exacerbate cardiovascular risk factors such as hypertension, dyslipidemia, and insulin resistance, further contributing to higher mortality rates in HIV-infected individuals. Additionally, decreased muscle mass, often observed in PLHIV due to a combination of ART side effects and HIV-related wasting syndrome, is a strong predictor of poor prognosis and increased risk of frailty, leading to higher mortality rates.

Recent data from cohort studies support these findings, showing that HIV-positive individuals with both central obesity and muscle wasting have a mortality rate significantly higher than those without these conditions, underscoring the critical need for early intervention and management of these comorbidities [30, 31]. In general, the presence of HIV in individuals living with HIV infection and other metabolic comorbidities increases the overall risk of mortality [32]. Addressing these cardiometabolic complications is vital for improving the long-term health outcomes of individuals living with HIV, emphasizing the importance of comprehensive care strategies that encompass both HIV management and the treatment of associated metabolic disorders [30, 31].

### 3.4 | Recommended Screening Protocols, Diagnosis, and Monitoring Guidelines for Cardiometabolic Conditions in HIV Patients

Given the heightened risk of cardiometabolic complications in people living with HIV (PLHIV), it is essential to employ comprehensive screening and monitoring strategies. Many current clinical guidelines advocate for a preventive approach to screening and monitoring techniques employed to assess and categorize the risk of cardiovascular complications in people infected by HIV, knowing that this class of patients is at higher risk of developing cardiometabolic conditions [33]. Many ongoing guidelines focus on a preventive strategy to screening, diagnosing and surveillance of cardiometabolic sequelae in people living with HIV (PLHIV). For instance, guidelines from the European AIDS Clinical Society (EACS) and the American Heart Association (AHA) emphasize periodic assessment of cardiovascular risk factors, lipid profiles, glucose metabolism, and body composition [34].

**TABLE 1** | Guidelines for screening, diagnosing, and monitoring for cardiometabolic condition in HIV patients.

| Cardiometabolic component | Screening protocol | Diagnostic criteria | Monitoring guidelines |
|---|---|---|---|
| Cardiovascular risk factors | Assessment of blood pressure, lipid profile, fasting sugar, and BMI (body composition) | high blood pressure ≥ 130 mmHg systolic or ≥ 85 mmHg diastolic; triglycerides ≥ 150 mg/dL, fasting blood glucose ≥ 100 mg/dL, physician-diagnosed diabetes, high-density lipoprotein cholesterol (HDL), BMI ≥ 30 kg/m$^2$ | Regular monitoring of blood pressure, lipid profile, fasting sugar, and BMI at least annually with echocardiographic follow-up, stress testing |
| Metabolic complications | Clinical evaluation and laboratory testing | Dyslipidemia, insulin resistance | Periodic clinical evaluation and laboratory testing |

According to the EACS guidelines, risk assessment tools such as the Framingham Risk Score or ASCVD Risk Calculator should be applied to quantify cardiovascular disease risk in PLHIV. Moreover, clinical monitoring of body weight and waist circumference can help identify patients with overweight or obesity, which are reported in over 60% of PLHIV and contribute to more than 30% of metabolic alterations. Dyslipidemia, observed in over 80% of PLHIV with metabolic changes, requires attention [16]. Diagnosis of cardiometabolic conditions in PLHIV can be concluded by involving physical examination, laboratory analysis and imaging studies as necessary. Laboratory assays and clinical signs can include: increased blood pressure ≥ 130 mmHg systolic or ≥ 85 mmHg diastolic; triglycerides ≥ 150 mg/dL, fasting plasma glucose ≥ 100 mg/dL, physician-diagnosed diabetes, high-density lipoprotein cholesterol (HDL) [16].

Moreover, echocardiography can be utilized to diagnose cases such as dilated cardiomyopathy and pericarditis [35]. Routine surveillance is critical for effective management. HIV patients with or at risk of cardiometabolic diseases should undergo regular monitoring of lipid levels, platelet activity, and blood pressure [36, 37], in line with EACS and International AIDS Society (IAS) guidelines. Serial monitoring helps assess the impact of ART on the heart and adjust treatments accordingly, as ART-related cardiac toxicity is a known concern [38, 39]. Early detection, intervention, and regular monitoring in the management of HIV-related cardiometabolic challenges is paramount for several reasons. In fact, patients living with HIV can get the chance to preserve their overall quality of life, enhance their disease knowledge, and get better disease management by regular and systematic monitoring for their cardiovascular health [39]. see Table 1 for a summary of key recommendations and screening protocols.

### 3.5 | Management Approaches for Cardiometabolic Challenges in HIV

Management approaches for Cardiometabolic Challenges in HIV require multifaceted strategy encompassing lifestyle modifications, pharmacological interventions along with the role of community and individuals. According to Woldu et al., the risk of cardiometabolic conditions in HIV patients can be influenced by many factors [9]. These can include: cigarette smoking, overweight and obesity in addition to sedentary. For that, lifestyle modifications would have a significant role in the management of cardiometabolic conditions in HIV. In fact, lifestyle optimization can include smoking cessation due to its role in increasing the risk of atherosclerosis and myocardial infarction [16]. In addition, physical activity can lead to an amelioration in inflammation and cardiometabolic wellness.

Besides, dietary interventions and weight management are highly recommended for the management of cardiometabolic conditions in HIV patients [16]. These interventions can include: increased consumption of seafood, vegetables, fruits, legumes, and whole grains while restricting the consumption of: alcohol, sweets and sweetened beverage consumption, and red meats [40]. Furthermore, pharmacological interventions can be taken to manage and lower the risk of CVDs in HIV patients. Lipid-lowering drugs (statins) along with antiretroviral drug (ART) are important to lower the LDL in patients with HIV thus helping control lipid levels in these patients [40]. Additionally, glucose-lowering medications can introduce cardiac benefits in HIV patients. Based on a study conducted by Butale et al., HIV patients on glucose-lowering medications experienced a reduction in blood pressure, improved lipid levels, and ameliorated insulin sensitivity, all of which can help in controlling cardiometabolic conditions [41].

Hypertension which is a lead cause for CVDs has a significantly higher rate in people with HIV compared to normal people, thus, it is important for HIV patient to receive antihypertensive medications especially for those under ART therapy [42]. The management of cardiometabolic conditions in HIV patients can be influenced by the education level, residential location, and healthcare literacy. As a result, multidisciplinary care teams can all work together for better management. This can include clinical pharmacist engagement, nurse management, co-located clinics that can provide integrated and comprehensive care, enhancing accessibility to health insurance, and electronic medical record-based strategies to target patients with elevated risk [40]. Moreover, community campaigns can deliver screening and scanning services for HIV patients. Campaigns and health fairs can also play a vital role in providing patient education which can improve diagnosis times and make treatment accessible [43]. According to Okonji et al., in order for young people living with HIV to improve compliance and maintenance in ART care, it is important for them to get psychological and emotional support that can be either from support groups, professional counseling centers, and family support [43, 44],

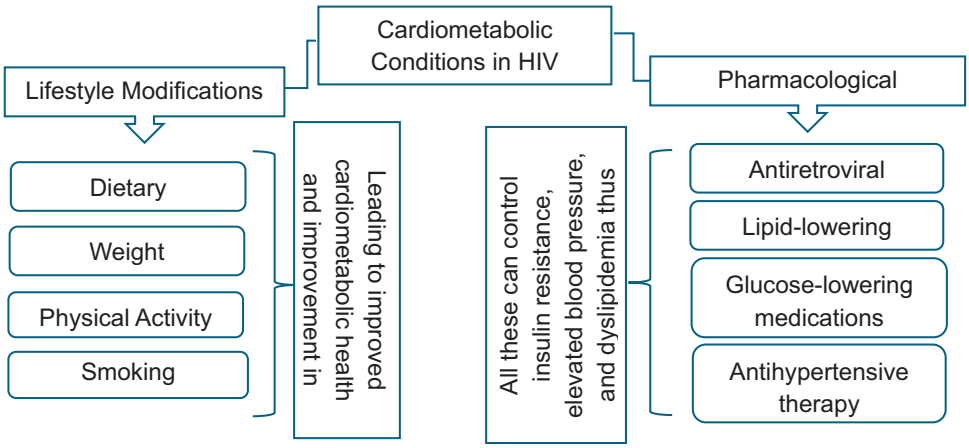


**FIGURE 2** | Integrated approach to cardiometabolic management in HIV: A flowchart guide.

Thus, the actions of multidisciplinary teams, the community and family have a significant effect on the health of patients infected with HIV (see Figure 2).

### 3.6 | Challenges, Barriers and Future Perspectives in the Management of Cardiometabolic Conditions in HIV Patients

Although several therapeutic strategies have been developed to mitigate the cardiometabolic burden in people living with HIV (PLHIV), numerous challenges persist, necessitating a forward-looking perspective to address these issues effectively.

1. Socioeconomic barriers and healthcare disparities

   Several studies have concluded that socioeconomic factors play an important role in defining the treatment of acquired immunodeficiency syndrome (AIDS) [44]. Low education level, low income, unemployment, unstable housing, poverty and deprivation, stigma, and low socioeconomic status might result in less adherence to the treatment of AIDS [44, 45]. Addressing these inequities through supportive platforms, community-based programs, and policy interventions is critical for improving patient outcomes.

2. Impact of antiretroviral therapy (ART) on metabolic health

   Studies showed that HIV and the anti-retroviral therapy (ART) itself, especially integrase strand transfer inhibitors (INSTIs) and tenofovir alafenamide (TAF), are highly correlated with changes in the immune system, body fat alterations, weight gain, and cardiometabolic diseases (CMDs) [46–48]. Bailin et al. conducted an investigative trial to examine the effect of ART in the metabolome/lipidome [49]. The results showed significant variations in these molecules in PLHIV in comparison to HIV-negative people [49]. These changes propose increased lipogenesis and inflammation in LVHIV adhering to ART, elevated triacylglycerols (TAGs) in patients taking raltegravir (RAL) compared to those taking the atazanavir/ritonavir (ATV/r) or darunavir/ritonavir (DRV/r) [49]. These findings underscore the need for personalized treatment strategies that balance effective HIV suppression with the minimization of CMD risks.

3. Inflammation and metabolic alterations

   Cardiac problems can also be influenced by other metabolic alterations, such as diabetes, obesity, and inflammation [50]. The role of glucose and lipids in inducing CMDs in PLHIV remains unclear [50]. Small, randomized trials were conducted, which highlighted good results in decreasing lipids levels and reducing cardiovascular problems in HIV-positive patients [51]. However, broad-scale randomized studies are necessary to prevent CMDs in patients infected with HIV [49]. When it comes to inflammation, it was unclear whether its reduction might relieve cardiac fat deposition [51]. A randomized trial concluded that an interleukin-1β blocker, the canakinumab, reduced two signals, the interleukin-6 and the CRP levels, alongside myocardial infraction in PLHIV [51]. Additionally, HIV-induced microbiome alterations and translocation to the gut might present a risk to CMDs; therefore, it would be interesting to dive into more strategies that target the gut microbiome in treating CMDs in PLHIV [52]. The association between HIV and cardiometabolic problems remains underestimated, and it is suggested to undertake more studies to find more therapeutic approaches [51].

4. Smoking and lifestyle modification

   Smoking cessation is a critical intervention the help lowering the CMDs risk, even more than the selection of the ART or the use of hypolipidemic drug, making it an important target in the future [9]. Lifestyle modifications, including weight management and cardiovascular risk assessments, should be integrated into routine care to address underlying CMD risk factors more comprehensively.

5. Research gaps and future directions

HIV continues to be one of the world's most significant and serious health concerns [53]. A lot of obstacles may present, making it difficult to adhere to the correspondent treatment. First, a big misconception is that the HIV pandemic has become well- controlled, and that it has been resolved as a global issue [54, 55]. Therefore, it is very essential to increase the preventative measures, especially in low-income regions [48, 55]. Introducing supportive platforms and programs for people living with HIV facing social disparities can be the most effective solution for these populations [46, 55]. Broader clinical trials are

also necessary to evaluate the efficacy of anti-inflammatory therapies, gut microbiome-targeted interventions, and ART regimens tailored to minimize CMD risks. Furthermore, increased global efforts to combat misconceptions about the HIV pandemic and prioritize prevention measures are essential for mitigating CMD complications in PLHIV [55].

## 4 | Conclusion

As conclusion, addressing cardiometabolic challenges in HIV: Insights, Impact, and Best Practices for Optimal Management offers a thorough analysis of the relationship between cardiometabolic health and HIV infection. This review emphasizes the value of early detection, proactive screening, and customized therapies to improve the management of cardiometabolic problems in people living with HIV, optimize outcomes and enhance the quality of life for individuals who are affected, and guide clinical practice by synthesizing the most recent research to mitigates risks and outcomes. This review also shows that early detection through regular screening is pivotal through collaboration between healthcare providers, researchers, and policymakers, which will allow for timely interventions and drive innovation and address evolving challenges, hence enhancing the quality of life for individuals living with HIV and reduce the burden of cardiometabolic complications. By continuing to do research and advocacy efforts, not only will advance knowledge but also improve the long-term health outcomes for people living with HIV.

### Author Contributions

**Nadine Mugisha:** writing – original draft, writing – review and editing, data curation. **Laura Ghanem:** writing – original draft, writing – review and editing, data curation. **Omar A. I. Komi:** writing – original draft, data curation. **Rawan Noureddine:** writing – original draft, data curation. **Sanobar Shariff:** writing – original draft, data curation. **Magda Wojtara:** writing – original draft, writing – review and editing, data curation. **Mahlagha Mousavi Nanehkeran:** writing – original draft, data curation. **Olivier Uwishema:** conceptualization, writing – original draft, writing – review and editing, project administration, supervision, formal analysis, investigation, validation, data curation.

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### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The authors have nothing to report.

### Transparency Statement

The lead author Olivier Uwishema affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained. All co-authors approved the final manuscript. All co-authors have read and approved the submission.

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