Syndemic Associations of Alcohol Use, Condom Use, and Psychological Distress with Viral Load Non-Suppression among People Living with HIV in Uganda:

An Analysis of UPHIA 2020–2021 Data

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DECLARATION

I, Emmanuel Len Opio, declare that this thesis is my original work and has not been submitted for the award of a degree or for examination at any other university or institution of higher learning.

Where the work of others has been used, whether from printed, digital, or other sources, it has been duly acknowledged and referenced in accordance with academic standards.

This thesis is submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science in Public Health and Health Equity** at **the KIT Institute and Vrije Universiteit Amsterdam.**

I affirm that the content presented is the result of my own independent research and that all ethical considerations and approvals have been duly observed and obtained where necessary.

Signed: 

Date: 6 August 2025

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
aOR	Adjusted Odds Ratio
ART	Antiretroviral Therapy
AUDIT-C	Alcohol Use Disorders Identification Test Consumption
BIC	Bayesian Information Criterion
HIV	Human Immunodeficiency Virus
LCA	Latent Class Analysis
MoH	Ministry of Health
OR	Odds Ratio
PEth	Phosphatidylethanol
PHIA	Population-based HIV Impact Assessment
PLHIV	People Living with HIV
SAVA	Substance Abuse, Violence, and AIDS Syndemic
UAC	Uganda AIDS Commission
UNAIDS	Joint United Nations Programme on HIV/AIDS
UPHIA	Uganda Population-based HIV Impact Assessment
US	United States
VLS	Viral Load Suppression
VLNS	Viral Load Non-Suppression
WHO	World Health Organization

ABSTRACT

Despite widespread antiretroviral therapy (ART) coverage, viral load non-suppression (VLNS) remains a significant public health challenge in Uganda. Psychosocial and behavioral factors such as harmful alcohol use, psychological distress, and condom non-use may compromise HIV treatment outcomes yet their combined effects are poorly understood. This study applied a syndemic framework to examine individual and joint associations of these factors with VLNS among people living with HIV (PLHIV) using data from the 2020 2021 Uganda Population based HIV Impact Assessment (UPHIA).

Latent class analysis identified distinct risk profiles based on co-occurring vulnerabilities. Multivariable logistic regression assessed associations between latent class membership and VLNS (>1,000 copies/mL) adjusting for sociodemographic and clinical covariates.

Harmful alcohol use and psychological distress were each significantly associated with increased odds of VLNS among PLHIV on ART while condom non-use was not. The higher risk syndemic class defined by overlapping harmful alcohol use psychological distress and condom non-use had significantly higher odds of VLNS compared to the lower risk class. This syndemic effect showed a stronger association with VLNS than most individual exposures highlighting the synergistic impact of these vulnerabilities. The higher risk class included more men but other sociodemographic and geographic factors did not differ significantly. Interaction analyses indicated consistent syndemic effects across demographic and geographic subgroups.

Findings emphasize the need for integrated HIV services addressing mental health substance use and sexual health with some differentiated targeting for men and disadvantaged groups alongside policy reforms and health system strengthening to improve viral suppression in Uganda.

Keywords HIV Syndemic Viral Load Alcohol Use Uganda

INTRODUCTION

My professional journey in HIV programming spans the past nine years and has significantly shaped my understanding of Uganda's HIV epidemic and its complex psychosocial and behavioral dimensions. I have worked both full-time and as a consultant with nongovernmental organizations and community-based organizations, supporting the design, implementation, and evaluation of interventions targeting vulnerable groups. These include rural and urban communities affected by HIV, adolescent girls and young women, fishing communities, and key populations. Notably, I led an HIV/TB-focused research and advocacy Community Led-Monitoring project across 22 districts in the formerly war-torn Northern Uganda, holding PEPFAR implementing partners, local governments, and health facilities accountable for HIV service delivery.

These roles and my work with Boundless Development Initiative, which I co-founded, exposed me to the widespread influence of syndemics: overlapping psychosocial and behavioral challenges that compound HIV-related risks and treatment outcomes. My curiosity was further heightened by informal observations in social environments, especially nightclubs, bars, and day-to-day social interactions, where the dynamics of alcohol use and related behaviors were evident.

In 2021, during clinic and community monitoring visits in Northern Uganda, I met "Anna" (not her real name), a 40-year-old woman living with HIV who had been bedridden for at least two years. She lived in a dilapidated grass thatched hut with her five children, aged 3 to 20; tragically, all but the youngest were also living with HIV. The family faced dire poverty and food insecurity, and only one of the five HIV-positive members had achieved viral load suppression. Her eldest daughter, aged 20, had become the family's breadwinner while also serving as a peer supporter to other young people living with HIV. This experience underscored that viral load suppression is not just a biomedical milestone; it is influenced by a complex web of social, economic, and behavioral factors.

These personal and professional encounters deepened my commitment to understand the broader structural and behavioral drivers of HIV risk and treatment outcomes. Although my professional background has been rooted in qualitative research, I deliberately chose a quantitative approach for this thesis, both to strengthen my analytical skills and to test whether the syndemic patterns I had observed in communities are evident in nationally representative data.

The central aim of this thesis is therefore to investigate whether, and to what extent, psychosocial and behavioral syndemics, specifically alcohol use, condom use, and psychological distress, are associated with viral load suppression among people living with HIV in Uganda, using nationally representative data. By examining these associations, I hope to inform the development of more integrated, effective, and contextually grounded strategies for HIV programming in Uganda

CHAPTER 1: BACKGROUND

This chapter presents the background to the study, including an overview of the HIV epidemic globally and in Uganda, the rationale for the research, and the objectives guiding the investigation. It establishes the context and significance of the research problem and defines the scope and direction of the thesis.

1.1 Background

The Human Immunodeficiency Virus (HIV) remains a major global health challenge, with nearly 40 million people living with HIV (PLHIV) and over 600,000 Acquired Immune Deficiency Syndrome (AIDS)-related deaths reported worldwide in 2023.[1,2] Sub-Saharan Africa continues to bear the greatest burden, accounting for over 60% of global AIDS-related deaths and two-thirds of all PLHIV. In Uganda alone, an estimated 1.49 million people were living with HIV in 2023, with a national adult HIV prevalence of 5.1%. In the same year, there were 38,000 new infections and 20,000 AIDS-related deaths.[3]

Despite substantial progress in expanding access to antiretroviral therapy (ART) and reducing new HIV infections in Uganda, a significant proportion of PLHIV continue to experience viral non-suppression.[3–6] This undermines individual health, epidemic control, and the achievement of the UNAIDS 95-95-95 targets. According to the Uganda AIDS Commission(UAC),[3] the country was approaching the first target in 2023, with 92% of PLHIV aware of their HIV status which is an increase from 80.9% reported in the 2020–2021 Uganda Population-Based HIV Impact Assessment (UPHIA)[4]. However, ART coverage among those diagnosed has declined from 96.1% (UPHIA)[4] to 83% (UAC),[3] and viral suppression among those on treatment has dropped from 92.2% (UPHIA)[4] to 79% (UAC).[3] While such shifts may reflect methodological differences between data sources, they also point to persistent challenges in sustaining ART adherence and achieving viral suppression, challenges likely influenced by structural, behavioral, and psychosocial barriers.

Viral non-suppression has serious consequences. It increases the risk of HIV transmission, including sexual and mother-to-child transmission, which undermines epidemic control.[7,8] Ongoing viral replication under suboptimal treatment can lead to drug-resistant strains, limiting current and future treatment options.[9] Individuals with unsuppressed viral loads face greater risks of immune decline, opportunistic infections, and AIDS-related illness.[7,10] At the population level, high rates of non-suppression can fuel transmission networks and strain health systems.[7]

Recent suspensions and reductions in HIV funding by the United States (U.S.) President's Emergency Plan for AIDS Relief (PEPFAR),[11,12] along with shifting priorities among major donors like the Global Fund,[13] are compounding current challenges in Uganda, where nearly 60% of the HIV response depends on donor funding.[11] These funding gaps threaten the health system's capacity, including supply chains, service delivery, and community linkage networks vital for testing, treatment initiation, and adherence support[12].

Beyond biomedical and system-level factors, individual behaviours and mental health play a critical role in treatment outcomes.[14–16] A growing body of research highlights the importance of syndemic theory in understanding HIV outcomes.[17,18] Introduced by Singer,[19] the concept describes how co-occurring health conditions interact synergistically within contexts of social disadvantage. The framework has since expanded to include behavioral, psychological, and structural factors that jointly worsen health outcomes.[20] This thesis applies this perspective to examine how alcohol use, condom non-use, and psychological distress influence HIV viral load suppression in Uganda, whose combined presence is hereinafter referred to as the syndemic.

Alcohol consumption is prevalent among PLHIV,[21] and its harmful use has implications for HIV acquisition, transmission, and treatment outcomes. First, it contributes to increased risky sexual behavior, such as having numerous sexual partners, engagement with high-risk partners, sexual violence, and inconsistent condom use.[22] Second, it is associated with poor ART adherence,[23] which increases the likelihood of viral non-suppression and the development of drug resistance. Third, chronic alcohol use weakens the immune system, making individuals more vulnerable to comorbidities and accelerated HIV disease progression.[21] These risks are especially concerning in Uganda, which ranks first in Africa and fifth globally for alcohol consumption, averaging 12.2 liters of pure alcohol per capita annually.[24] Approximately 65% of alcohol production and sales remain unregulated,[25,26] and recent attempts to introduce alcohol control legislation were rejected by Parliament[26] complicating efforts to address alcohol-related harms and their impact on the HIV response.[25,27]

Mental health issues are prevalent among PLHIV, with high rates of both depression[28–32] and anxiety[33]. The relationship between alcohol use and mental health is particularly concerning, as the two are closely interlinked, tend to exacerbate one another, and independently contribute to poor HIV-related outcomes.[28,34] For instance individuals engaging in high-risk or hazardous alcohol use are significantly more likely to experience psychological distress[35] which may further undermine their ability to consistently take antiretroviral therapy (ART) or access supportive care.[36,37]

Condom use remains essential for preventing HIV transmission and superinfection, particularly among individuals who have not achieved viral suppression.[38,39] However, condom non-use continues to be a challenge and is often linked to alcohol use and psychological distress, which impair judgment, reduce the ability to negotiate safer sex, and increase sexual risk-taking.[40] These factors not only elevate the risk of HIV transmission and acquisition of other sexually transmitted infections but are also associated with poor ART adherence, ultimately contributing to viral non-suppression.[36,41,42] these interrelated risks highlight the need for a syndemic approach to improving HIV treatment outcomes in Uganda.

1.2 Problem Statement

Despite growing recognition of the syndemic framework, research in Uganda has often examined alcohol use, condom use, and psychological distress in isolation or within specific subpopulations, typically using small or non-representative samples.[43–46] There is limited evidence from large, nationally representative studies that systematically assess the syndemic effects of these factors on key HIV treatment outcomes such as viral suppression and ART adherence. Examining co-occurring psychosocial and behavioral factors in isolation may underestimate their combined influence on HIV treatment outcomes, as suggested by syndemic theory[18]. Much of the existing research in Uganda focuses on HIV risk behaviors, STI co-infections, and the substance abuse, violence, and AIDS (SAVA) syndemic, as illustrated by studies such as these.[43,46,47]

Although Uganda has a strong foundation in HIV research, the limited number of syndemic studies conducted to date have predominantly relied on additive models, conventional regression analyses, or qualitative methods to examine the effects of co-occurring risk factors on HIV outcomes.[43,44,46–49] Such approaches may fail to capture the synergistic interactions at the heart of syndemic theory, potentially underestimating the cumulative burden these factors impose on HIV treatment outcomes.[18,50]

To the best of my knowledge, no published study has systematically examined the combined influence of alcohol use, psychological distress, and condom non-use on viral suppression among people living with HIV in Uganda, particularly using nationally representative data and latent class analysis (LCA) to assess their associations. This study addresses that gap by applying a syndemic framework to the 2020–2021 Uganda Population-Based HIV Impact Assessment (UPHIA) data, using latent class analysis and interaction term modeling to assess both the individual and combined associations of these factors with viral suppression.

1.3 Justification

Understanding how co-occurring behavioral and psychosocial factors jointly influence viral suppression is critical for developing more integrated and responsive HIV care strategies in Uganda.[51] Since alcohol use, condom non-use, and psychological distress often overlap and may interact synergistically, analyzing them in isolation risks masking their full impact on treatment outcomes.[40,43,51,52] Applying a syndemic framework to nationally representative data allows for a more comprehensive understanding of how these factors cluster and contribute to viral non-suppression among PLHIV.[51]

The findings from this study can inform the design of differentiated care models that address not only clinical needs but also the broader psychosocial realities faced by people on ART. Integrating psychosocial support into HIV service delivery is a key recommendation in both global HIV treatment guidelines[36,53] and Uganda's national frameworks.[54] By identifying vulnerable subgroups and clarifying how risk factors cluster and interact, this analysis supports the development of more targeted and responsive interventions. These efforts are essential to improving viral suppression and advancing Uganda's progress toward epidemic control, including achievement of the UNAIDS 95–95–95 targets.

1.4 Objectives

To examine the individual and combined (syndemic) effects of alcohol use, condom use, and psychological distress on HIV viral load suppression among people living with HIV on ART in Uganda, using nationally representative data, and to explore how these effects vary across demographic, socioeconomic, and geographic subgroups.

Specific objectives:

1. To describe and compare the prevalence of alcohol use, condom use, and psychological distress among PLHIV and HIV-negative individuals in Uganda.
2. To assess the individual associations of alcohol use, condom use, and psychological distress with HIV viral non-suppression among PLHIV on ART.
3. To examine whether the syndemic presence of these factors is associated with higher odds of HIV viral non-suppression compared to each factor alone among PLHIV on ART.
4. To determine whether the association between syndemic burden and HIV viral non-suppression varies by demographic, socioeconomic, and geographic subgroups among PLHIV on ART.
5. To develop recommendations to inform HIV care and treatment strategies based on the study's findings.

CHAPTER 2: METHODS

This chapter outlines the data source, research design, and setting. It describes the sampling approach, study population, ethical considerations, data management, key variables, and statistical methods. These components establish a rigorous framework to investigate the syndemic effects of alcohol use, condom use, and psychological distress on viral load suppression among PLHIV in Uganda.

2.1 Data source, study design, and setting

This study utilized secondary data from the Uganda Population-based HIV Impact Assessment (UPHIA) 2020–2021. UPHIA 2020–2021 was a nationally representative, cross-sectional household survey conducted by the Uganda Ministry of Health in partnership with the U.S. Centers for Disease Control and Prevention (CDC) and ICAP at Columbia University, with funding from PEPFAR. The survey was conducted between February 2020 and March 2021.[5]

2.2 Sampling and study population

This survey employed a two-stage stratified cluster sampling design across 11 regions. A total of 26,071 individuals aged 15 years and older were interviewed, with 25,479 participants completing biomarker testing.(Ministry of Health, Uganda, 2024a, 2024b) For this analysis, the sample sizes varied by objective, with the largest sample including all participants with biomarker data, and smaller subsets restricted to HIV-positive individuals on ART with complete data on relevant variables.

2.3 Ethical considerations

UPHIA study materials and protocols received ethical approval from the Uganda National Council for Science and Technology, the Uganda Virus Research Institute, Columbia University Medical Center, Westat, and CDC. Informed consent was obtained from all participants, with assent and parental consent for minors. Consent covered interviews, HIV testing, sample storage, and data use. Participants unable to consent were excluded[5].

2.4 Weighting and Statistical Considerations

Sampling and jackknife replicate weights (JK2 method), provided in the UPHIA dataset, were applied to account for the complex, multistage survey design, including adjustments for selection probabilities, nonresponse, and post-stratification to the 2014 Census. These procedures were applied consistently across all descriptive and inferential analyses to ensure nationally representative estimates.[5,55,56]

2.5 Data Management

2.5.1 Data Preparation

Four datasets (household roster, household-level, individual adult interview, and biomarker) were obtained from the Population-based HIV Impact Assessment (PHIA) Project[57] in CSV format (see authorization in **Annex E 1**). These were imported into R version 4.5.0 (2025) and merged using household and individual identifiers to create a comprehensive analytical dataset containing demographic, behavioral, and biomarker information for each adult respondent. The household roster dataset was not used as it did not contain data relevant to the study. All subsequent analyses were conducted in R.

2.5.2 Handling Missing Values

The UPHIA dataset was generally clean, with missing values resulting from skip logic built into the data collection tools. In this analysis, these were converted to NA (Not Available) in R software, which is R's standard way of representing missing data.[58] Responses of "Do not know" or "Refused" were also recoded as NA due to their very low frequencies, to avoid influential outliers or sparse categories. Complete case analysis was employed throughout, excluding participants with missing data on outcome, exposure, or covariate variables. Although this reduced the sample size, it avoided assumptions inherent in imputation methods and supported valid estimation of associations.[59,60]

2.6 Study variables and operational definitions

2.6.1 Outcome variable: Viral load suppression

The outcome variable, viral load suppression (VLS), a widely accepted marker of treatment effectiveness, was defined as <1,000 copies/mL, in line with WHO guidelines.[61–63] In the UPHIA dataset, it was provided as "vls" but was recoded for this analysis as 0 = suppressed and 1 = not suppressed, to reflect suppressed as the reference category and non-suppression as the outcome of interest.

2.6.2 Exposure variable 1: Harmful alcohol use

Alcohol use was measured using the composite Alcohol Use Disorders Identification Test–Consumption (AUDIT-C), a validated three-item screening tool.[64–66] The composite AUDIT-C score was calculated from three UPHIA dataset variables: frequency of alcohol use (alcfreq), number of drinks on a typical drinking day (alcnumday), and frequency of consuming six or more drinks on one occasion (alcsixmore). Alcohol use was then categorized using established gender-specific AUDIT-C thresholds: non-user (score = 0), low-risk (men: 1–3; women: 1–2), and harmful use (men: ≥4; women: ≥3).[67] These categories were coded as 1, 2, and 3, respectively, for analysis

2.6.3 Exposure variable 2: Psychological distress

Psychological distress was assessed using the Patient Health Questionnaire-4 (PHQ-4), a validated four-item instrument for detecting symptoms of anxiety and depression.[68–71] For analysis, the PHQ-4 score (range: 0–12) was calculated by summing the PHQ-2 (depression) and GAD-2 (anxiety) scores provided in the UPHIA dataset, with higher scores indicating greater distress. A binary variable was created: scores ≤3 were classified as "No Distress" (coded 1), and scores >3 as "Distressed" (coded 2), consistent with UPHIA subscale cutoffs and slightly above the standard threshold of ≥3 commonly used in population screening.[68]

2.6.4 Exposure variable 3: Condom use

Condom use was assessed using the UPHIA variable condomlastsex12months, which captures condom use at the last sexual encounter within the past 12 months. For this analysis, the original three-category variable was recoded into two: individuals reporting condom use or no recent sexual activity were grouped as "Condom/No sex" (coded 1), indicating lower risk; those reporting no condom use were coded as 2 ("No condom"), indicating higher risk. This variable is hereinafter referred to as "condom use."

2.6.5 Demographic, socioeconomic and geographic covariates

Demographic, socioeconomic and geographic covariates relevant to VLS were obtained from the UPHIA dataset; some were recoded due to low counts and to improve regression model fit, as summarized in Table 1.

Table 1: Summary of covariates and variable recoding

Covariate	Categories / Recoding Details
Gender	Male, Female as provided
Age group	Recoded into five categories: 15–24, 25–34, 35–44, 45–54, and 55+ (merged original 55–64 and 65+ into 55+)
Marital status	Collapsed into three categories: never married, married/cohabiting, formerly married (divorced/separated and widowed merged)
Education	Recoded into three categories: no education, primary, and secondary+ (secondary and more than secondary merged)
Wealth quintile	Five quintiles used as provided, based on household asset index ranging from lowest to highest
Residence	Used as provided: Urban, Rural (per UPHIA and Uganda Bureau of Statistics criteria)
Region	Collapsed from 11 regions into 4 categories based on HIV prevalence from UPHIA[5] [4]: Low (<4%), Medium (4–5.9%), High (6–6.9%), Very High (≥7%)

2.7 Statistical Analysis

2.7.1 Regression Modeling

To assess associations between key exposures and viral load non-suppression, survey-weighted logistic regression models were fitted using the svyglm() function in R. This approach accounted for the complex survey design by incorporating sampling weights, clustering, and stratification through replicate weights.[72,73] Both unadjusted and adjusted models used a quasibinomial family to address the binary outcome and potential over dispersion.[74]

Demographic, socioeconomic, and geographic covariates selected a priori included age group, gender, marital status, education level, household wealth quintile, place of residence (urban or rural) and region. These variables were consistently adjusted for in all multivariable analyses.

2.7.2 Descriptive Analysis (Objective 1)

To compare the prevalence of alcohol use, condom use, and psychological distress among PLHIV and HIV-negative individuals, descriptive statistics were stratified by HIV status. Unweighted frequencies and percentages described the sample, while weighted prevalence estimates with 95% confidence intervals accounted for the complex survey design.[56] Differences by HIV status were tested using the Rao-Scott adjusted chi-square test, with p-values reported in summary tables.

2.7.3 Individual Associations Between Key Exposures and VLNS (Objective 2)

To address the second objective, survey-weighted logistic regression models were fitted to assess the association between the key exposure variable and HIV viral load non-suppression. Two models were estimated: an unadjusted model including only the exposure and outcome variables, and an adjusted model controlling for covariates detailed in Section 2.7.1. Crude odds ratios (ORs) and adjusted odds ratios (aORs), along with 95% confidence intervals and p-values, were reported to quantify the strength and direction of association.

Comparing unadjusted and adjusted estimates allowed for assessment of potential confounding by covariates. Similarity between crude and adjusted estimates was interpreted as minimal confounding, while substantial changes suggested possible influence of the covariates. Additionally, results from the adjusted models were examined to identify any covariates that may be independently associated with viral load non-suppression, regardless of exposure status.

2.7.4 LCA: Model Fit and Syndemic Associations with VLNS (Objective 3)

To address the third objective, latent class analysis (LCA) was used. LCA is a person-centered statistical technique that identifies unobserved subgroups within a population based on response patterns across multiple categorical variables.[75–77] This approach allowed for empirical identification of distinct risk profiles reflecting co-occurring psychosocial and behavioral vulnerabilities.[50,75–77] The LCA model included the three exposure variables: alcohol use, condom use, and psychological distress. To ensure valid class estimation, the analysis was restricted to HIV-positive individuals with complete data on all three exposures, reducing the analytic sample from 1,483 to 1,105. Models specifying two, three, and four latent classes were fitted[76] using 20 random starts and a maximum of 10,000 iterations to ensure convergence.[77] Final model selection was guided by the Akaike Information Criterion (AIC), Bayesian

Information Criterion (BIC), log-likelihood, and entropy.[75,76] Lower AIC and BIC values indicated better model fit, while higher entropy values suggested clearer class separation and better classification quality. AIC and BIC are statistical measures that balance model fit and complexity, where lower values indicate a better fit with less overfitting. Higher entropy values suggest clearer class separation and better classification quality.[75–77]

Participants were assigned to the latent class for which they had the highest posterior probability of membership, reflecting the likelihood of class membership given their observed responses.[75,77] This modal assignment approach is standard in LCA when entropy is acceptable and class separation is clear.[77] These class assignments were then used as categorical indicators of syndemic burden in subsequent regression analyses.

Regression Analysis for Syndemic Effects

Following the assessment of individual risk factors in Objective 2, a separate multivariable regression model was specified with latent class membership as the primary exposure variable and HIV viral load non-suppression (VLNS) as the outcome. The model adjusted for covariates detailed in 2.7.1 above. To isolate the syndemic effect represented by the latent classes, the three key exposure variables used in the latent class model were excluded from the regression to avoid multicollinearity. The analysis was restricted to HIV-positive participants with valid latent class assignments.

To evaluate whether latent class membership was more strongly associated with viral load non-suppression than the individual exposures, the results were compared to those from the Objective 2 models. Since AIC and BIC, which are commonly used for model comparison, are not valid for survey-weighted models, comparisons focused on effect sizes, p-values, and the added conceptual value of the person-centered syndemic framework. Stronger associations, such as higher adjusted odds ratios and statistically significant p-values for syndemic class membership compared to the individual exposures, were interpreted as evidence of a more meaningful syndemic effect.

2.7.5 Subgroup Analysis of Syndemic Associations (Objective 4)

To address the fourth objective, a two-stage analytical strategy was employed.

First, differences in the distribution of key demographic, socioeconomic, and geographic subgroups, including gender, age group, education level, wealth quintile, marital status, region, and urban-rural residence, were examined between the two syndemic risk classes. Survey-weighted and unweighted descriptive analyses were conducted to compare subgroup proportions across classes. For each subgroup within each class, unweighted counts, weighted proportions, and 95% confidence intervals were calculated. Design-adjusted Rao-Scott chi-square tests assessed whether these subgroup differences were statistically significant.

Second, to evaluate whether the association between syndemic risk class and viral load suppression varied across these subgroups, survey-weighted logistic regression models were fitted. Each model included an interaction term between syndemic class and one demographic, socioeconomic, or geographic characteristic, adjusting for the remaining characteristics as covariates. Odds ratios and 95% confidence intervals were reported, and Wald tests with p-values less than 0.05 were used to assess the significance of the interaction terms. Significant interactions indicated effect modification, meaning that the strength or direction of the association between syndemic class and viral load suppression differed across the relevant subgroups.

CHAPTER 3: RESULTS

This chapter presents the key findings from the analysis of harmful alcohol use, condom non-use, and psychological distress, both individually and in combination, and their associations with viral load suppression among people living with HIV. It begins by examining the prevalence of these key exposures by HIV status, followed by unadjusted and adjusted associations with viral load non-suppression. The chapter then explores latent class analysis to identify distinct risk profiles and examines how these syndemic profiles relate to viral load outcomes. Finally, subgroup analyses assess whether these associations vary by key demographic and geographic characteristics.

3.1 Results: Sociodemographic Characteristics of Study Participants by HIV Status

Table 2 presents the sociodemographic characteristics of study participants stratified by HIV status. Among PLHIV, a higher proportion were female (weighted: 65.1%, 95% CI: 63.0–67.2) compared to their HIV-negative counterparts (51.7%, 95% CI: 51.6–51.9). PLHIV were also more likely to be older: 57.6% were aged 35 years and above, compared to only 33.6% of HIV-negative individuals. Conversely, youth aged 15–24 accounted for 41.3% of the HIV-negative group but only 12.5% of PLHIV.

Marital status patterns also differed: a substantially larger proportion of PLHIV were formerly married (35.7%) compared to HIV-negative individuals (14.5%), while a greater share of the HIV-negative group had never married (32.7% vs. 9.6%).

Educational attainment showed modest variation, with PLHIV being slightly more likely to have only primary education (60.6% vs. 51.8%) and slightly less likely to have attained secondary education or higher (28.8% vs. 40.0%).

In terms of household wealth, the distribution among PLHIV was relatively even across quintiles, though they were slightly more concentrated in the middle three quintiles. In contrast, HIV-negative individuals were more likely to fall into the lowest wealth quintile (21.5% vs. 17.7%).

Residence status also differed: 40.3% of PLHIV lived in urban areas, compared to 32.4% of HIV-negative individuals, suggesting greater urban representation among those with HIV.

By region, PLHIV were more likely to reside in areas with higher HIV prevalence. Specifically, 37.0% lived in regions classified as having very high HIV prevalence (≥7%), compared to only 26.3% of HIV-negative individuals. Conversely, only 4.3% of PLHIV resided in low-prevalence regions (<4%), compared to 9.7% of those who were HIV-negative.

Table 2: Demographic Characteristics of Study Participants by HIV Status

Variable / Category	HIV Positive		HIV Negative	
	Unweighted (n, %)	Weighted (%, 95% CI)	Unweighted (n, %)	Weighted (%, 95% CI)
Gender				
Female	1,016 (68.5%)	65.1 (63.0–67.2)	13,887 (57.9%)	51.7 (51.6–51.9)
Male	467 (31.5%)	34.9 (32.8–37.0)	10,109 (42.1%)	48.3 (48.1–48.4)
Age group				
55+	173 (11.7%)	10.4 (8.7–12.0)	3,087 (12.9%)	10.1 (10.0–10.2)
45–54	324 (21.8%)	19.7 (17.6–21.9)	2,592 (10.8%)	8.9 (8.8–9.1)
35–44	426 (28.7%)	27.5 (24.9–30.2)	3,882 (16.2%)	14.6 (14.4–14.8)
25–34	396 (26.7%)	29.9 (27.1–32.6)	5,719 (23.8%)	25.1 (24.9–25.2)
15–24	164 (11.1%)	12.5 (10.4–14.5)	8,716 (36.3%)	41.3 (41.1–41.5)
Marital status				
Married/cohabiting	792 (53.5%)	54.7 (51.5–57.9)	13,510 (56.4%)	52.9 (52.0–53.7)
Formerly married	561 (37.9%)	35.7 (32.7–38.7)	3,900 (16.3%)	14.5 (14.0–14.9)
Never married	128 (8.6%)	9.6 (7.8–11.4)	6,554 (27.3%)	32.7 (31.9–33.4)
Education				
Secondary+	414 (28.0%)	28.8 (26.1–31.5)	8,388 (35.0%)	40.0 (37.9–42.0)
Primary	887 (59.9%)	60.6 (58.0–63.2)	12,436 (51.9%)	51.8 (50.0–53.6)
No education	180 (12.2%)	10.6 (9.1–12.2)	3,154 (13.2%)	8.3 (7.8–8.7)
Wealth quintile				
Highest	271 (18.3%)	18.2 (14.6–21.8)	3,857 (16.1%)	18.2 (15.7–20.8)
Fourth	311 (21.0%)	22.8 (19.4–26.3)	3,728 (15.5%)	18.1 (16.0–20.2)
Middle	321 (21.6%)	23.2 (20.0–26.5)	4,550 (19.0%)	21.5 (19.6–23.4)
Second	260 (17.5%)	18.0 (15.0–21.1)	4,643 (19.4%)	20.6 (18.7–22.6)
Lowest	320 (21.6%)	17.7 (14.7–20.7)	7,212 (30.1%)	21.5 (19.3–23.7)
Residence				
Urban	596 (40.2%)	40.3 (32.5–48.0)	7,240 (30.2%)	32.4 (27.0–37.8)
Rural	887 (59.8%)	59.7 (52.0–67.5)	16,756 (69.8%)	67.6 (62.2–73.0)
Region				
Very high HIV prevalence (≥7%)	445 (30.0%)	37.0 (31.8–42.2)	4,721 (19.7%)	26.3 (23.6–29.1)
High HIV prevalence (6–6.9%)	497 (33.5%)	31.7 (27.2–36.2)	6,943 (28.9%)	29.6 (27.3–32.0)
Medium HIV prevalence (4–5.9%)	403 (27.2%)	27.0 (23.2–30.8)	7,483 (31.2%)	34.4 (32.2–36.6)
Low HIV prevalence (<4%)	138 (9.3%)	4.3 (2.2–6.4)	4,849 (20.2%)	9.7 (8.7–10.6)

Note: Unweighted counts (n) represent the actual number of respondents in each category. Weighted percentages (%) reflect national population estimates adjusted for survey design and sampling probabilities.

3.2 Prevalence of Key Exposures by HIV Status (Objective 1)

To address objective 1, the prevalence of alcohol use, condom use, and psychological distress was examined and compared by HIV status. These findings are summarized in Table 3, which presents both unweighted sample counts and weighted national estimates with 95% confidence intervals.

Table 3: Prevalence of Alcohol Use, Condom Use, and Psychological Distress by HIV Status

Variable / Category	HIV Positive		HIV Negative		P-value
	Unweighted (n, %)	Weighted (%, 95% CI)	Unweighted (n, %)	Weighted (%, 95% CI)	
Alcohol use					
Non-users	946 (64.4%)	64.4 (61.5–67.3)	16,702 (70.2%)	74.0 (73.0–75.1)	<0.001***
Low-risk	314 (21.4%)	21.3 (18.8–23.8)	3,724 (15.6%)	15.3 (14.6–16.1)	
Harmful	208 (14.2%)	14.3 (12.2–16.4)	3,373 (14.2%)	10.6 (10.0–11.2)	
Condom use					
Condom/No sex	569 (40.0%)	37.6 (34.6–40.5)	6,164 (30.0%)	29.5 (28.6–30.5)	<0.001***
No condom	854 (60.0%)	62.4 (59.5–65.4)	14,383 (70.0%)	70.5 (69.5–71.4)	
Psychological distress					
No distress	1,029 (70.0%)	71.0 (68.1–73.8)	19,228 (81.5%)	83.2 (82.3–84.0)	<0.001***
Distressed	441 (30.0%)	29.0 (26.2–31.9)	4,371 (18.5%)	16.8 (16.0–17.7)	

Note: n = unweighted sample count; % = weighted percentage with 95% confidence interval (CI).
P-values from Rao-Scott adjusted chi-square test for complex survey data.
*** $p < 0.001$ indicates statistical significance.

The prevalence of harmful alcohol use, psychological distress, and condom use or no sex differed significantly between PLHIV and HIV-negative individuals, all ($p < 0.001$).

Among PLHIV, 21.3% were classified as low-risk alcohol users and 14.3% as harmful users, compared to 15.3% and 10.6%, respectively, among HIV-negative individuals. Non-use of alcohol was more common among HIV-negative individuals, 74.0%, than among PLHIV, 64.4%.

Condom use or no sex at last encounter was reported by 37.6% of PLHIV and 29.5% of HIV-negative individuals. In contrast, non-condom use was more common among HIV-negative individuals, 70.5%, than among PLHIV, 62.4%.

Psychological distress was present in 29.0% of PLHIV, significantly higher than the 16.8% observed among HIV-negative individuals.

3.3 Unadjusted and Adjusted Associations of Key Exposures with VLNS (Objective 2)

To address Objective 2, individual associations between alcohol use, condom use, and psychological distress with viral load non-suppression were estimated and compared using unadjusted and adjusted (multivariable) logistic regression models. The results are summarized in Table 4.

Table 4: Unadjusted and Adjusted Associations Between Key Exposures and VLNS

Variable / Category	Crude OR	95% CI	p-value	aOR	95% CI	p-value
Alcohol use						
Non-users (ref)						
Low-risk	1.59	0.89–2.82	0.114	1.79	0.92– 3.47	0.085
Harmful	2.31	1.29–4.16	0.005**	2.63	1.34–5.14	0.005**
Condom use						
Condom/No sex (ref)						
No condom	1.37	0.83–2.28	0.220	1.01	0.5–1.78	0.981
Psychological distress						
No distress (ref)						
Distressed	1.66	1.0–2.67	0.038*	1.69	1.01–2.81	0.044*

$p < 0.05$ (*), $p < 0.01$ (**).
OR = Odds Ratio; aOR = Adjusted Odds Ratio; CI = Confidence Interval; Ref = Reference category.
Estimates account for survey design and sampling weights.

In both unadjusted and adjusted models, harmful alcohol use was significantly associated with increased odds of viral load non-suppression. After adjusting for covariates, harmful alcohol use remained associated with 2.63 times higher odds of viral non-suppression (95% CI: 1.34–5.14; p = 0.005). Low-risk alcohol use was associated with increased odds of viral load non-suppression in both unadjusted and adjusted models, but these associations did not reach statistical significance (aOR = 1.79, 95% CI: 0.92–3.47, p = 0.085).

No condom use was not significantly associated with viral load non-suppression in either the unadjusted or adjusted models. In the adjusted model, the odds ratio was 1.01 (95% CI: 0.50–1.78; p = 0.981).

Psychological distress was significantly associated with viral load non-suppression in both models. After adjustment, distressed individuals had 1.69 times higher odds of non-suppression compared to those not distressed (95% CI: 1.01–2.81; p = 0.044).

Across all adjusted models, certain covariates, such as age and wealth quintile, were independently associated with viral load non-suppression. Participants aged 15–34 had significantly higher odds of non-suppression, and those in lower wealth quintiles, especially the poorest group, also showed substantially higher odds. Region may also play a role; individuals in medium HIV prevalence areas (4–5.9%) had higher odds of non-suppression, with statistically significant associations in two of the three models. Other covariates, including gender, marital status, education, and residence, were not consistently associated with the outcome.

Detailed regression outputs for the unadjusted model are provided in **Annex Table A 1**, while results for the adjusted models are shown in **Annex Table B 1**, **Annex Table B 2**, and **Annex Table B 3**.

In summary, only harmful alcohol use and psychological distress remained independently associated with viral load non-suppression after adjusting for covariates. The adjusted odds ratios for all exposure categories were generally consistent with their corresponding crude odds ratios.

3.4 Results: LCA: Model Fit and Syndemic Associations with VLNS (Objective 3)

3.4.1 Latent Class Analysis Model Fit and Selection

Objective 3 examined whether the syndemic presence of these factors is associated with worse HIV viral non-suppression than each factor alone. As a first step in the latent class analysis, latent classes were selected by comparing 2-class, 3-class, and 4-class models. Table 5 summarizes the model fit statistics and classification quality measures for each model.

Table 5: Model Fit Statistics for Latent Class Analysis

No. Classes	AIC	BIC	Log-Likelihood	Entropy	Alerts
2	4752.091	4797.159	-2367.045	0.912	None
3	4760.617	4830.723	-2366.308	0.434	Maximum likelihood not found, negative DF
4	4770.616	4865.761	-2366.308	0.257	negative DF; respecify model

AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; DF = Degrees of Freedom. Total N = 1,105. Analytic sample includes HIV-positive participants on ART with complete exposure data.

The two-class model demonstrated the best overall combination of statistical fit and classification quality among those tested. Specifically, it had the lowest AIC (4752.09) and BIC (4797.16) values, as well as the highest entropy (0.912), indicating a clearer separation between classes and greater certainty in class assignment.

Although both the three-class and four-class solutions achieved marginally higher log-likelihoods, they exhibited higher AIC and BIC values (reflecting poorer fit) and substantially lower entropy (0.434 and 0.257, respectively), suggesting weaker distinction between classes. Importantly, both models also suffered from estimation problems: the three-class model produced a “maximum likelihood not found” warning and negative degrees of freedom, while the four-class model also reported negative degrees of freedom. Based on these statistical and diagnostic criteria, the two-class model was selected as the optimal solution for subsequent analyses.

Following the selection of the two-class model, participants were assigned to latent classes based on their highest posterior probabilities of class membership. As shown in Table 6, the mean posterior probability was 1.000 for Class 1 and 0.979 for Class 2, indicating a high level of classification certainty for both groups.

Table 6: Classification Certainty and Estimated Class Proportions for LCA Model

Class	Estimated Proportion	Participants Assigned (n)	Participants Assigned (%)	Mean Posterior Probability
1	0.136	130	11.8	1.000
2	0.864	975	88.2	0.979

Note: Total N = 1,105. Analytic sample includes HIV-positive participants on ART with complete exposure data n = unweighted count; % = percentage of analytic sample.

This strong classification quality, together with the distinct class proportions, suggests that the model performed well and that the identified classes are appropriate for use in subsequent analyses. Class 1 comprised 11.8% of participants (n = 130), while Class 2 comprised 88.2% (n = 975).

3.4.2 Syndemic Associations with VLNS

To interpret the substantive meaning of each class, the conditional response probabilities for each category of the exposure variables were examined. These probabilities, presented in **Table 7Error! Reference source not found.**, indicate the likelihood that a participant, given their membership in a particular latent class, reports a specific level or category of exposure.

Table 7: Conditional Probabilities of Exposure Categories Given Latent Class Membership

Exposure variable / category	Probability given class 1	Probability given class 2
Alcohol use		
Non-user	0.00	0.78
Low-risk	0.14	0.22
Harmful	0.86	0.00
Psychological Distress		
No distress	0.59	0.70
Distressed	0.41	0.30
Condom use		
Condom/No sex	0.31	0.45
No condom	0.69	0.55

Class 1, which accounted for approximately 11.8% of participants, was characterized by a very high probability of harmful alcohol use (0.86), moderate probabilities of psychological distress (0.41), and a high probability of reporting no condom use during last sex (0.69). This class had negligible likelihood of being non-users of alcohol (0.00) and relatively low likelihood of condom use or sexual abstinence (0.31).

In contrast, Class 2, comprising about 88.2% of the sample, was predominantly made up of non-users of alcohol (0.78), had a lower probability of psychological distress (0.30), and a greater likelihood of condom use or abstinence (0.45) compared to Class 1. The probability of harmful alcohol use in this class was (0.00).

For ease of interpretation and comprehension, subsequent analyzes hereafter refer to the identified classes as the "Higher Risk Class" (originally Class 1) and the "Lower Risk Class" (originally Class 2), based on their observed and distinct patterns of alcohol use, psychological distress, and condom use. These latent class memberships serve as a proxy for syndemic burden in subsequent analyses.

After assigning and labelling latent classes, a logistic regression model was fitted to examine whether the syndemic effect, represented by class membership, was associated with HIV viral load non-suppression. This model adjusted for the same socioeconomic and geographical covariates used in the adjusted logistic regression model from Objective 2 (Table 4), which assessed the individual exposure variables. A comparison of results from these models is presented in Table 8 to evaluate whether the syndemic effect was more strongly associated with HIV viral load non-suppression than the individual exposures alone.

Table 8: Individual vs Syndemic Effects of Risk Factors on HIV Viral Load Non-Suppression

Variable / Category	Adjusted OR	Std. Error	Lower 95% CI	Upper 95% CI	P-value
Alcohol use					
Non-users (ref)					
Alcohol use (Low-risk)	1.79	0.34	0.92	3.47	0.085.
Alcohol use (Harmful)	2.63	0.34	1.34	5.14	0.005**
Condom use					
Condom/No sex (ref)					
No condom	1.01	0.29	0.57	1.78	0.981
Psychological distress					
No distress (ref)					
Distressed	1.69	0.26	1.01	2.81	0.044*
Syndemic effect					
Lower risk class (ref)					
Higher risk class	2.48	0.34	1.27	4.85	0.008**

OR = Odds Ratio; CI = Confidence Interval; Ref = Reference category.
p-values: $p < 0.05$ (*), $p < 0.01$ (**); "." indicates marginal significance ($0.05 < p < 0.10$).
Analytic sample includes HIV-positive participants on ART with complete exposure data (N = 1,105).

Harmful alcohol use was significantly associated with increased odds of viral load non-suppression (AOR = 2.63, 95% CI: 1.34–5.14, p = 0.005), whereas low-risk alcohol use showed a non-significant trend toward higher odds (AOR = 1.79, 95% CI: 0.92–3.47, p = 0.085). Psychological distress was also significantly associated with higher odds of viral non-suppression (AOR = 1.69, 95% CI: 1.01–2.81, p = 0.044). In contrast, reporting no condom use at last sex was not significantly associated with viral non-suppression (AOR = 1.01, 95% CI: 0.57–1.78, p = 0.981).

Belonging to the Higher Risk latent Class was independently associated with more than double the odds of viral load non-suppression compared to the Lower Risk Class (AOR = 2.48, 95% CI: 1.27–4.85, p = 0.008).

Comparing across models, the syndemic (Higher Risk Class) effect exhibited a stronger association with viral non-suppression than any individual exposure, except for harmful alcohol use, which had the highest adjusted odds ratio.

These findings indicate that harmful alcohol use and the syndemic (Higher Risk Class) effect showed the strongest associations with viral load non-suppression, while condom non-use and low-risk alcohol consumption were not significantly associated in adjusted models.

In the syndemic effects model, younger age, low wealth, and region were significantly associated with viral load non-suppression. Compared to those 55+, individuals aged 25–34 and 15–24 had higher odds of non-suppression (OR=5.10, 95% CI: 2.02–12.88; p<0.001 and OR=5.38, 95% CI: 1.33–21.85; p=0.020, respectively). Those in the lowest wealth quintile also had increased odds (OR=5.50, 95% CI: 2.00–15.13; p=0.001), as did individuals in medium HIV prevalence regions compared to high prevalence (OR=1.86, 95% CI: 1.06–3.27; p=0.032). Gender, marital status, education, and urban/rural residence showed no significant associations. These findings align with results from Objective 2.

Detailed regression outputs for the syndemic effects model are provided in **Annex Table C 1**

3.5 Results: Characteristics by Latent Classes and Interaction Analysis (Objective 4)

3.5.1 Sociodemographic Characteristics by Latent Class

To address Objective 4, an initial descriptive analysis was conducted to compare the distribution of key sociodemographic and geographic characteristics across the two latent classes. **Table 9** presents these distributions, along with p-values assessing class differences.

A significantly higher weighted prevalence of viral load non-suppression was observed among individuals in the Higher Risk Class (13.9%; 95% CI: 7.5–20.3%) compared to those in the Lower Risk Class (6.6%; 95% CI: 4.9–8.2%) (p = 0.005). Conversely, viral load suppression was more common in the Lower Risk Class (93.4%; 95% CI: 91.8–95.1%) than in the Higher Risk Class (86.1%; 95% CI: 79.7–92.5%). These findings indicate a statistically significant difference in viral load outcomes between the two latent classes.

Table 9: Sociodemographic Characteristics by Latent Class and Class Differences

Variable / Category	Lower Risk Class			Higher Risk Class			p-value
	Unweighted		Weighted	Unweighted		Weighted	
	n	%	% (95% CI)	n	%	% (95% CI)	
Viral suppression							
Suppressed	907	93.4	93.4 (91.8–95.1)	113	86.9	86.1 (79.7–92.5)	0.005**
Not suppressed	64	6.6	6.6 (4.9–8.2)	17	13.1	13.9 (7.5–20.3)	
Gender							
Female	697	71.8	69.1 (66.3–71.8)	78	60.0	54.1 (46.5–61.6)	0.000***
Male	274	28.2	30.9 (28.2–33.7)	52	40.0	45.9 (38.4–53.5)	
Age group							
55+	128	13.2	12.3 (10.0–14.5)	14	10.8	9.2 (4.3–14.1)	0.713
45–54	236	24.3	21.9 (18.8–25.0)	36	27.7	25.7 (18.7–32.8)	
35–44	285	29.4	28.4 (25.3–31.5)	40	30.8	30.4 (21.8–39.1)	
25–34	256	26.4	29.4 (26.3–32.6)	31	23.8	26.2 (19.1–33.4)	
15–24	66	6.8	8.0 (6.0–9.9)	9	6.9	8.3 (2.7–14.0)	
Marital status							
Married/cohabiting	547	56.3	57.9 (54.1–61.7)	62	47.7	47.5 (38.4–56.6)	0.082.
Formerly married	365	37.6	35.5 (31.8–39.2)	56	43.1	43.1 (33.9–52.2)	
Never married	59	6.1	6.6 (4.8–8.3)	12	9.2	9.5 (4.1–14.8)	
Education							
Secondary+	270	27.8	28.1 (25.1–31.2)	34	26.2	29.3 (20.5–38.2)	0.964
Primary	581	59.8	60.5 (57.3–63.6)	78	60.0	59.6 (49.6–69.5)	
No education	120	12.4	11.4 (9.4–13.4)	18	13.8	11.1 (6.0–16.2)	
Wealth quintile							
Highest	187	19.3	18.7 (14.6–22.7)	21	16.2	21.0 (12.2–29.8)	0.843
Fourth	186	19.2	20.6 (16.8–24.4)	29	22.3	20.9 (11.7–30.0)	
Middle	222	22.9	25.1 (21.4–28.9)	29	22.3	20.7 (12.4–29.1)	
Second	182	18.7	19.3 (15.5–23.1)	21	16.2	18.2 (10.2–26.2)	
Lowest	194	20.0	16.3 (13.0–19.5)	30	23.1	19.2 (12.7–25.6)	
Residence							
Urban	389	40.1	40.2 (32.0–48.3)	59	45.4	45.8 (32.3–59.3)	0.323
Rural	582	59.9	59.8 (51.7–68.0)	71	54.6	54.2 (40.7–67.7)	
Region							
Very high HIV prev (≥7%)	290	29.9	36.7 (30.9–42.5)	38	29.2	40.6 (29.2–51.9)	0.277
High HIV prev (6–6.9%)	328	33.8	31.8 (26.8–36.8)	40	30.8	29.6 (19.2–40.0)	
Medium HIV prev (4–5.9%)	272	28.0	27.5 (23.2–31.9)	29	22.3	22.6 (14.3–30.8)	
Low HIV prevalence (<4%)	81	8.3	4.0 (2.2–5.8)	23	17.7	7.3 (0.7–13.8)	

Significance codes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, . $p < 0.1$; Not significant ($p \geq 0.1$)
n = unweighted count; % = weighted percentage adjusted for survey design
Total analytic sample includes HIV-positive participants on ART with complete exposure data (N = 1,101).

Among the sociodemographic characteristics assessed, gender was the only variable that differed significantly between classes ($p < 0.001$). The Higher Risk Class had a greater weighted proportion of male participants (45.9%; 95% CI: 38.4–53.5%) compared to the Lower Risk Class (30.9%; 95% CI: 28.2–33.7%). In contrast, a higher proportion of female participants was observed in the Lower Risk Class (69.1%; 95% CI: 66.3–71.8%) compared to the Higher Risk Class (54.1%; 95% CI: 46.5–61.6%).

No other sociodemographic, economic, or geographic characteristics were found to be statistically significantly different between classes. Although differences in marital status approached statistical significance ($p = 0.082$), they did not meet the conventional threshold ($p < 0.05$) and were therefore considered marginally significant.

3.5.2 Interaction Effects of Syndemic Class and Subgroup Characteristics on VLNS

To assess whether the association between syndemic risk class and viral load suppression varied across subgroups, interaction terms between syndemic class and each sociodemographic or geographic characteristic were added to survey-weighted regression models. **Table 10** presents the odds ratios and 95% confidence intervals for each interaction. No significant differences were observed across subgroups.

None of the interaction terms between syndemic class and subgroup characteristics were statistically significant at the $p < 0.05$ level, indicating no evidence that the effect of syndemic class on viral load non-suppression varied by gender, age group, region, education level, marital status, wealth quintile, or residence. A borderline significant interaction was observed for the 15–24 age group (OR = 0.00; 95% CI: 0.00–1.17; $p = 0.05$); however, the estimate was highly imprecise due to the wide confidence interval. Overall, these findings suggest that the relationship between syndemic burden and viral load non-suppression was consistent across all examined demographic and geographic subgroups.

Across the subgroup-specific models, several main effects emerged as statistically significant predictors of viral load non-suppression. Younger age groups (15–24, 25–34, and 35–44 years) consistently had significantly higher odds of viral load non-suppression compared to the reference group aged 55 and above. In addition, being in the lowest wealth quintile was associated with a greater likelihood of viral load non-suppression across models. The main effect of syndemic class reached statistical significance in some models, indicating that individuals with a high syndemic risk were at increased risk of viral load non-suppression. Significant associations were also observed for other sociodemographic characteristics, such as region and marital status, in selected models. Detailed regression outputs for the interaction effects between syndemic class and subgroup characteristics on viral load non-suppression are provided in **Annex Table D 1, Annex Table D 2, Annex Table D 3, Annex Table D 4, Annex Table D 5, Annex Table D 6,** and **Annex Table D 7**

Table 10: Interaction Effects of Syndemic Risk Class and Subgroup Characteristics on VLNS

Variable / Model Term	Odds Ratio	Lower 95% CI	Upper 95% CI	P-value
Gender				
Reference: Female				
Syndemic class × Male	0.90	0.19	4.16	0.89
Age group				
Reference: 55+				
Syndemic class × 5–54	1.27	0.00	2.70e+11	0.99
Syndemic class × 35–44	0.51	0.00	9.43e+10	0.96
Syndemic class × 25–34	2.26	0.00	4.44e+11	0.95
Syndemic class × 15–24	0.00	0.00	1.17	0.05
Married				
Reference: Married/cohabiting				
Syndemic class × Formerly married	1.39	0.32	5.92	0.66
Syndemic class × Never married	1.42	0.00	3.35e+11	0.98
Education				
Syndemic class × Primary	0.35	0.08	1.46	0.15
Syndemic class × No education	0.18	0.00	9.67	0.40
Wealth quintile				
Reference: Highest				
Syndemic class × Fourth	0.74	0.08	7.01	0.79
Syndemic class × Middle	0.34	0.03	3.81	0.38
Syndemic class × Second	0.53	0.05	5.31	0.58
Syndemic class × Lowest	0.23	0.03	1.57	0.13
Residence (urban/rural)				
Reference: Urban				
Syndemic class × Rural	0.44	0.11	1.74	0.24
Region				
Reference: Higher risk *Very high HIV prevalence ≥7%)				
Syndemic class × High HIV prevalence (6–6.9%)	0.73	0.10	5.65	0.77
Syndemic class × Medium HIV prevalence (4–5.9%)	0.50	0.10	2.46	0.39
Syndemic class × Low HIV prevalence (<4%)	0.84	0.18	3.83	0.82

Significance codes: *** p < 0.001, ** p < 0.01, * p < 0.05, . p < 0.1; not significant (p ≥ 0.1)
CI = Confidence Interval; OR = Odds Ratio
Total analytic sample includes HIV-positive participants on ART with complete exposure data (N = 1,101).
Extreme or imprecise confidence intervals reflect sparse data in some subgroups.

CHAPTER 4: DISCUSSION

This chapter interprets and contextualizes the findings on the individual and combined associations of harmful alcohol use, condom non-use, and psychological distress with viral load suppression among PLHIV in Uganda. Building on the descriptive and inferential results presented in the previous chapter, the discussion highlights key insights into how these psychosocial and behavioral factors cluster within the population and how they relate to HIV treatment outcomes. Particular attention is given to the role of syndemic interactions, as identified through latent class analysis, and their implications for differentiated HIV care and intervention strategies. The chapter also examines variations across demographic, socioeconomic, and geographic subgroups, drawing out practical implications for targeted programming. Where relevant, the findings are compared with existing literature, and possible explanations, limitations, and policy implications are discussed.The chapter concludes by discussing study strengths and limitations and proposing directions for future research.

4.1 Discussion of Objective 1 Findings

The higher prevalence of both **low-risk** and **harmful alcohol use** among PLHIV aligns with a large rural Central Uganda study, which found greater alcohol consumption across all AUDIT-C levels among PLHIV43.[78] Similarly, analysis of the comparable 2016 Zambia PHIA dataset found more frequent moderate and unhealthy alcohol use among PLHIV.[79] Moreover, the higher proportion of HIV-negative individuals abstaining from alcohol compared to PLHIV is a consistent finding in other studies.[78,79]

Given alcohol's established role as a risk factor for HIV acquisition in sub-Saharan Africa,[80,81] the elevated prevalence among PLHIV may partly reflect pre-infection risk behaviors. It may also reflect alcohol use as a post-diagnosis coping mechanism to manage HIV-related stigma, psychological distress, or the broader challenges of living with a chronic condition.[82–84]

However, alcohol use is likely underreported in this study, as Ugandan studies comparing self-reported consumption to phosphatidylethanol (PEth) biomarker levels found significantly higher rates of alcohol use among PLHIV when measured objectively.[85,86]

In Uganda, few studies directly compare **psychological distress** between PLHIV and HIV-negative individuals, limiting understanding of the relative burden. Nevertheless, existing research consistently reports high levels of psychological distress among PLHIV, frequently exceeding 30%.[87,88]

The finding that psychological distress is significantly more prevalent among PLHIV than HIV-negative individuals in this study aligns with evidence from other sub-Saharan African contexts. Analysis of a nationally representative survey from South Africa[89] and a large-scale survey from Zimbabwe[90] also found higher psychological distress among PLHIV. Although these studies used different measurement tools (the K10 and the Shona Symptom Questionnaire, respectively),[89,90] the consistent pattern indicates higher psychological distress among PLHIV across diverse settings.

Evidence from across sub-Saharan Africa shows that while the drivers of psychological distress among PLHIV are somewhat similar, they also vary across contexts and subpopulations. Commonly cited factors include stigma and discrimination, poverty, unemployment, food insecurity, treatment-related side effects, alcohol dependency, limited access to care, post-traumatic stress disorder, chronic stress, and uncertainty about the future.[14,34,35,87,89,91–95] Although specific risk factors differ across studies, the evidence collectively points to a clustering of social determinants that increase the risk of psychological distress,[91] varying by demographic and subpopulation group. However, this study did not analyze data at such granularity.

The high levels of **condom non-use** observed among both PLHIV and HIV-negative individuals in this study align with broader evidence from sub-Saharan Africa, where low or inconsistent condom use is widely reported across populations.[96–99]

For instance, a hospital-based study in Nigeria found that only 51.5% of PLHIV used a condom at last sex,[97] while a meta-analysis of 33 studies (including Uganda) estimated consistent condom use at 44.7%.[99] In Uganda, previous studies reported that 46–51% of PLHIV did not use condoms consistently.[96,98] These figures are lower than those in the present study, where condom non-use was 62.4% among PLHIV and 70.5% among HIV-negative individuals. Interestingly, while this study found higher condom use or abstinence among PLHIV than HIV-negative individuals at last sex, other studies have reported lower or more inconsistent condom use among PLHIV.[100,101] This inconsistency across studies suggests no conclusive pattern in condom use between the two groups. The difference observed in this study may reflect the impact of prevention messaging and post-diagnosis counseling received by PLHIV.

This widespread pattern of low condom use may reflect overlapping behavioral risks and shared sexual networks shaped by common norms, partner dynamics, and structural conditions affecting both PLHIV and HIV-negative individuals. A broad body of literature from sub-Saharan Africa highlights that condom non-use is influenced by a complex mix of behavioral, relational, structural, and sociodemographic factors, including but not limited to alcohol use, psychological distress, preference for sero-negative partners, pursuit of increased sexual pleasure, and limited access to services.[40,102–104] While concerning for the general population, the consequences are especially concerning for PLHIV and those in serodiscordant relationships due to the heightened risk of onward transmission and reinfection with resistant strains,[105–107] particularly without the protective effect of viral suppression.[8,38,108,109]

Overall, this study found that harmful alcohol use and psychological distress were more prevalent among PLHIV than HIV-negative individuals in Uganda, consistent with prior research. Although both groups exhibited high levels of condom non-use, PLHIV reported slightly higher safer sex practices, contrasting with some earlier studies. These findings highlight the clustering of behavioral and psychosocial risks among PLHIV and provide important context for examining their individual and combined syndemic effects on HIV viral suppression in subsequent objectives.

4.2 Discussion of Objective 2 Findings

This study found that **harmful alcohol use** was significantly associated with VLNS among PLHIV on ART, similar to findings from Zambia[79] and South Africa.[110] In contrast, Wynn et al.[42] and Miller et al.[41], two Ugandan studies, found no such association among ART users. Notably, Wynn et al. applied a more stringent viral suppression threshold of <20 copies/mL, which may have reduced power to detect associations.[42] Miller et al., however, used the same ≤1,000 copies/mL threshold as this study.[41] The absence of associations in these two Ugandan studies, despite comparable or stricter thresholds, may reflect differences in sample size, measurement, or population characteristics. Overall, the findings from this study reinforce evidence that harmful alcohol use may compromise viral suppression even among those on ART.

Although this study did not find a significant association between low-risk alcohol use and VLNS, the observed trend toward increased odds suggests a possible dose–response effect. Preliminary analyses that included PLHIV not on ART found significant associations even at low-risk levels, indicating that ART may mitigate this risk. This pattern echoes results from a Kenya and Uganda study, where only very-high-level alcohol consumption was significantly associated with reduced viral suppression among those on ART, while lower levels showed no association.[111] These findings support a dose–response relationship, in which heavier alcohol use increasingly compromises viral suppression, even among those receiving ART.

This study's finding that **psychological distress** is significantly associated with VLNS contributes to a growing but mixed evidence base linking mental health to HIV treatment outcomes. In South Africa, one study among adolescents found depression, but not anxiety, associated with VLNS,[112] while another among youth reported no link with depressive symptoms or perceived stress.[113] Among South African female sex workers (FSWs) in eThekwini, depression was also linked to reduced viral suppression.[114] In Rwanda, a history of depression was associated with VLNS in bivariate analysis, but not in multivariable models.[115]

Evidence from North America is also mixed. Among adults on ART in the United States, those screening positive for severe mental illness had six times higher odds of having a detectable viral load.[116] A meta-analysis of studies from Canada and the US found that depression was significantly associated with viral non-suppression among women and the general population of people living with HIV, but not among men.[117] These inconsistencies may reflect variations in mental health screening tools, study populations, and definitions or thresholds of viral load non-suppression.

A plausible explanation for the observed association between psychological distress and VLNS in this study is poor ART adherence, as distress has been linked to suboptimal adherence, though this relationship tends to weaken when mental health care is accessible.[34] However, even among PLHIV receiving ART and intensive adherence counseling, both patient-related and health system barriers can limit the effectiveness of these support services.[118] Additionally, the relationship may be bidirectional: psychological distress can impair adherence and viral suppression, while uncontrolled HIV infection may exacerbate distress through biological and psychosocial mechanisms.[112]

Consistent with most prior studies, this analysis found no statistically significant association between **condom use** and VLNS among PLHIV in Uganda. Similar results have been observed elsewhere. A clinic-based study in South Africa found no association between condom use and VLNS (≥50 copies/mL).[119] Nationally representative data from Kenya showed that lack of condom use at last sex and inconsistent use were only marginally associated with VLNS in bivariate models ($p < 0.1$), and not significant after adjustment (VLNS ≥550 copies/mL).[120] Likewise, a U.S. study in Baltimore reported no significant association between condom use and VLNS (≥50 copies/mL).[121]

However, some studies, especially those including PLHIV not on ART, have reported different results. Preliminary analysis in this study, which included PLHIV not on ART, found a significant association between condom non-use and VLNS (>1,000 copies/mL). This aligns with findings from ZIMPHIA 2020[122] and a study in KwaZulu-Natal, South Africa,[123] both of which reported significant associations between condom non-use and VLNS among PLHIV regardless of treatment status. These patterns likely reflect unsuppressed viral load among undiagnosed and untreated individuals, who constitute a substantial portion of the survey datasets,[5,124–126] large enough to meaningfully influence the observed associations.

Overall, condom use does not appear to be a consistent predictor of viral non-suppression among PLHIV on ART, likely because viral suppression is mainly driven by adherence and clinical care.[8] Nonetheless, condoms remain essential for preventing transmission, especially among those not on treatment or not suppressed.[108]

4.3 Discussion of Objective 3 Findings

The finding that the syndemic class effect exceeded that of individual exposures, except harmful alcohol use, suggests a synergistic interaction, where co-occurring harmful alcohol use, psychological distress, and condom non-use elevate the risk of viral non-suppression beyond individual effects, consistent with syndemic theory.[127–129]

To the best of my knowledge, this is among the first studies in Uganda and one of relatively few in Sub-Saharan Africa to use LCA to examine syndemic patterns involving alcohol use, psychological distress, and condom use in relation to HIV viral suppression. In the absence of comparable regional research, this discussion draws on evidence from the United States, where both additive and latent class approaches have examined syndemics of substance use, mental health, and sexual risk and their association with viral non-suppression.[130–133]

Kuhns et al. in Chicago observed that ART adherence and viral suppression declined significantly with increasing syndemic burden among young people living with HIV.[131] Dawit et al. in Miami corroborated these findings in a large LCA involving substance use, mental health issues, and social adversity.[134] Glynn et al., also in Miami, reported that each additional syndemic factor, including unstable housing, depression, and substance use, was associated with higher odds of VLNS.[132] Friedman et al. found a dose-response increase in VLNS with an increasing number of co-occurring conditions, including substance use, depression, and sexual risk among men who have sex with men.[130]

In contrast, a study among female sex workers living with HIV in eThekwini, South Africa, found that although depression and the SAVA syndemic were each associated with viral non-suppression, their combined effect was weakened in multivariable models.[114] This attenuation may reflect the influence of other correlated factors like homelessness and stigma,[114] underscoring that the impact of psychosocial and behavioral vulnerabilities on HIV outcomes can vary across populations and be shaped by broader social determinants.

Although the syndemic effect was significantly associated with VLNS, harmful alcohol use showed an even stronger adjusted association, underscoring its central role as both an independent risk factor and key syndemic driver. Psychological distress, also independently linked to VLNS, may similarly amplify risk within the syndemic context, even if its role in class differentiation is less pronounced. While condom non-use was not independently associated with viral non-suppression, its higher prevalence in the high-risk class suggests it may still contribute to the syndemic burden through interactions with psychological distress and substance use, effects not fully captured in individual-level analyses.

4.4 Discussion of Objective 4 Findings

The absence of significant differences in the association between syndemic class and viral non-suppression across demographic and geographic groups suggests that the negative effects of syndemic burden on HIV treatment outcomes are not confined to specific subpopulations, but may affect PLHIV broadly across Uganda. This aligns with syndemic theory, which posits that co-occurring psychosocial and behavioral conditions can interact to produce population-level impacts on health.[128] While few studies in Uganda or Sub-Saharan Africa have used nationally representative data and latent class analysis to assess subgroup variation in syndemic effects, a population-based study in Southern Uganda reported persistently high STI prevalence among PLHIV despite widespread ART access, underscoring the continued relevance of syndemic-like conditions across diverse groups.[49]

Although interaction terms between syndemic class and age were not statistically significant overall, the result for the youngest group (15–24 years) approached significance, suggesting a potential differential effect. This borderline finding may reflect limited statistical power in smaller subgroups and aligns with programmatic data showing that viral non-suppression among adolescents in Uganda can match or exceed national averages.[135]

In the absence of statistically significant interaction effects, descriptive patterns still pointed to meaningful differences. Men were significantly overrepresented in the Higher Risk Class, suggesting greater overlap of psychosocial and behavioral risks. This aligns with regional evidence that men in Sub-Saharan Africa are more likely to engage in harmful alcohol use[78,136] and are less likely to know their HIV status or access and adhere to care.[54,137–140] As a result, despite higher HIV prevalence among women,[141,142] men experience higher HIV-related mortality.[54,138,143]

Similarly, younger adults (ages 15–34) and individuals in the lowest wealth quintile consistently showed higher odds of VLNS across multivariable models, reinforcing evidence that these groups face greater challenges in achieving optimal ART outcomes.[4,5,125,144,145] In Uganda, these disparities are compounded by the limited reach of government economic empowerment programmes for PLHIV, key and priority populations, particularly those who are not economically active, as such initiatives are typically demand-driven and often structured in ways that inadvertently exclude the most vulnerable.[6]

The absence of statistically significant subgroup differences does not suggest tailored interventions are unnecessary. Instead, it underscores the widespread impact of syndemic conditions on HIV outcomes across populations, supporting the need for integrated services that address mental health, substance use, and sexual health. At the same time, the overrepresentation of men in the Higher Risk Class and elevated VLNS odds among young adults and those with low socioeconomic status point to the value of targeted approaches, including differentiated service delivery and youth- and male-friendly services.

Although not the focus of this study, key populations experience higher rates of harmful alcohol use, condom non-use, and psychological distress, often compounded by stigma, criminalization, and restricted access to care.[54,146,147] These intersecting vulnerabilities may amplify syndemic effects. Yet, such groups are frequently underrepresented in household surveys like UPHIA, limiting their visibility.[148,149] Syndemic-informed strategies must therefore be adapted to address the specific needs of key populations.

Persistent structural and policy-level challenges continue to undermine Uganda's HIV response and complicate the implementation of syndemic-informed care. Recent reductions and suspensions in critical funding, including from PEPFAR and other major donors,[11,12] have, among other effects, led to the closure of dedicated HIV clinics and the retrenchment of facility- and community-based health workers, further burdening an already overstretched health system.[150–152] These disruptions raise serious concerns about the system's capacity to integrate multi-component interventions that address co-occurring psychosocial and behavioral risks. At the same time, Uganda's largely unregulated alcohol market and Parliament's recent rejection of proposed control legislation[25,26] hinder efforts to reduce alcohol-related harms. Without stronger investment in healthcare infrastructure and the adoption of supportive regulatory frameworks, efforts to improve treatment outcomes may remain fragmented and inequitable.

4.5 Strengths and limitations

Strengths

This study is among the first in Uganda to apply syndemic theory using LCA to identify patterns of harmful alcohol use, psychological distress, and condom non-use among PLHIV. By using data from the nationally representative UPHIA 2020–2021 survey which includes biomarker-based viral load measures, the study employed a person-centered analytic approach that strengthens both the internal and external validity of its findings. The use of objective viral suppression data, rather than self-report, enhances the reliability of outcome measurement and the generalizability of results.

A second strength lies in the integration of syndemic theory as a guiding framework for both hypothesis development and interpretation. This enabled assessment of not just individual risk factors, but also their potential synergistic effects on HIV outcomes. In addition, subgroup analyses by gender, age, socioeconomic status, residence, and region increased the policy relevance of the findings.

Limitations

Despite its strengths, this study has several limitations. Most importantly, the cross-sectional design of the UPHIA survey restricts the ability to infer causality or temporal sequencing between syndemic exposures and VLNS. Key exposures, including harmful alcohol use, psychological distress, and condom use, were self-reported and may be affected by recall or social desirability bias[153 154], potentially underestimating the true prevalence of risk behaviors.

Measurement limitations also arise from the brief screening tools used. The AUDIT-C and PHQ-4, though widely validated and practical for large-scale surveys,[65 66 68 71 70] may not fully capture the severity or diagnostic spectrum of alcohol misuse and psychological distress. Similarly, the single-item measure of condom use at last sex does not reflect consistency, contextual factors, or correct use.[155 156 157]. More nuanced indicators, such as condom use with high-risk or non-marital partners, were excluded due to low frequencies, which limited the depth of behavioral risk assessment.

Certain sociodemographic variables, such as age, marital status, education, and region were collapsed into broader categories to ensure model fit and stability. While analytically necessary, this may have masked important subgroup distinctions. The use of complete-case analysis also excluded individuals with any missing exposure, outcome, or covariate data, potentially introducing selection bias if excluded individuals differed systematically from those included.

Although subgroup interaction tests were performed, small sample sizes in some strata may have reduced statistical power to detect significant variation in syndemic effects. Unmeasured confounding remains another concern, as critical variables such as ART adherence, HIV-related stigma, and comorbidities were not used in this analysis, potentially biasing associations between exposures and viral suppression.

Variation in measurement tools and variable definitions across studies posed challenges for comparative interpretation during the discussion phase, making it difficult to synthesize findings within the broader literature.

The LCA approach itself introduces additional limitations. LCA depends on the selection of input indicators and assumes that individuals belong to distinct, mutually exclusive classes.[158] This assumption may not fully reflect the continuum, overlap, or fluidity of syndemic conditions in real life.[18] Some degree of misclassification is inherent in the probabilistic nature of LCA. In this study, the final model was restricted to two latent classes due to convergence issues with models specifying more classes.[76] As a result, potentially meaningful subgroups may not have been detected, limiting the granularity of syndemic profiling. It is important to interpret these classes as analytical groupings derived from data rather than fixed or naturally occurring categories, particularly when informing intervention design.

Finally, household surveys like UPHIA often underrepresent or exclude key and priority populations or hidden populations. These groups are known to experience elevated syndemic burden and face unique structural barriers to care. As such, the findings of this study may not be generalizable to the populations most vulnerable to the compounded effects of psychosocial and behavioral health risks.

4.6 Future Research Directions

This study highlights several areas requiring further investigation. Longitudinal and mixed-methods research is needed to clarify the causal pathways linking co-occurring psychosocial and behavioral risks to HIV treatment outcomes. Improved measurement using validated diagnostic tools, biomarker-confirmed alcohol use, and more detailed indicators of condom use would enhance accuracy and risk estimation.

Larger samples of people living with HIV are essential to support more disaggregated subgroup analysis. In this study, sparse data limited statistical power and model stability, especially when attempting to fit models with three or more latent classes. It is likely that additional meaningful subgroups exist but could not be reliably detected due to convergence issues.

Comparative studies that include both individuals on and off ART would offer a more complete picture of syndemic burden across the treatment continuum. Further research should also prioritize key populations often excluded from household surveys, using targeted or community-based sampling approaches to assess syndemic burden and treatment outcomes. Finally, expanding the use of latent class and geospatial modeling in larger datasets could uncover more nuanced risk patterns and regional disparities, helping to guide more tailored and equitable programmatic responses.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the study's key findings, draws conclusions, and presents targeted recommendations to inform policy, treatment, and care approaches aimed at improving viral suppression among PLHIV. It closes with final reflections on implications and future directions.

5.1 Conclusions

This study examined the individual and combined effects of harmful alcohol use, condom non-use, and psychological distress on HIV VLNS among PLHIV in Uganda, using data from UPHIA 2020–2021. The study aimed to assess the prevalence of these risk factors, evaluate their syndemic clustering using LCA, and determine their impact, individually and in combination, on viral non-suppression, including potential variation across demographic and geographic subgroups.

The findings revealed that harmful alcohol use and psychological distress were significantly more prevalent among PLHIV than among HIV-negative individuals, with condom non-use remaining widespread in both groups. Latent class analysis identified a small but distinct subgroup of PLHIV (11.8% of the sample) characterized by a high probability of co-occurring alcohol use, condom non-use, and moderate probability of psychological distress. Membership in this higher-risk class was significantly associated with increased odds of viral non-suppression, supporting the presence of a syndemic effect.

Crucially, these results demonstrate that the co-occurrence of behavioral and psychosocial risks, conceptualized through a syndemic framework, compounds the likelihood of VLNS. The identified high-risk subgroup reflects a population facing structural and service delivery gaps that routine ART programs may not be fully equipped to address. Notably, the combination of all three risk factors exerted a stronger adverse effect on VLS than any factor alone, except for alcohol use alone, underscoring the need for integrated, person-centered approaches.

Although the association between syndemic burden and viral non-suppression did not significantly vary across demographic or geographic groups, several descriptive patterns pointed to meaningful differences. Men were disproportionately represented in the Higher Risk Class, reflecting greater overlap of psychosocial and behavioral vulnerabilities, such as harmful alcohol use and lower engagement in HIV care. Similarly, younger adults (ages 15–34) and individuals in the lowest wealth quintile consistently exhibited higher odds of viral non-suppression across models, reinforcing known disparities in ART outcomes. The near-significant result for adolescents (15–24 years), along with ongoing programmatic concerns about their treatment outcomes, suggests this group may be particularly vulnerable. These findings indicate that while syndemic effects are broadly distributed, certain populations may face heightened risks that may benefit from targeted approaches within inclusive, universal service models.

To address these challenges, policy and programmatic realignment is urgently needed. This includes integrating behavioral health and psychosocial support within HIV care, strengthening data systems to routinely capture syndemic indicators, and investing in multi-sectoral strategies that address the root causes of risk. The involvement of communities, peer networks, and key populations must be central to this shift.

By adopting a syndemic lens and moving beyond siloed, prevention-focused responses, Uganda can make meaningful progress toward the UNAIDS 95-95-95 goals. More importantly, such a shift would help ensure that HIV care models reflect the realities and lived experiences of PLHIV, particularly those facing multiple, intersecting challenges.

5.2 Recommendations

5.2.1 High-Level Policy Recommendations

- **Integrate Syndemic Frameworks into National HIV Strategies**

  The Ministry of Health (MoH) and Uganda AIDS Commission (UAC) should revise existing policies to formally incorporate syndemic approaches addressing co-occurring harmful alcohol use, psychological distress, and social determinants that hinder viral suppression among PLHIV. Adequate funding and resources should be allocated to support the implementation, monitoring, and evaluation of these integrated interventions.

- **Strengthen Alcohol Control Policies to Reduce Harmful Use**
  Given the significant impact of harmful alcohol use on viral load non-suppression, review, update, and enforce evidence-based alcohol control legislation, including restrictions on sales, advertising, and access. Further integrate alcohol harm reduction strategies within national HIV programs to reduce syndemic risks.

- **Mandate Social Protection within HIV Policy**
  Embed systematic screening for economic vulnerability and establish formal referral pathways to livelihood and social support programs within HIV care protocols to address poverty as a key syndemic driver of poor treatment outcomes.

5.2.2 Treatment-Level Recommendations

- **Scale Up Integrated HIV Care Models**
  Institutionalize routine mental health and alcohol use screenings (e.g., PHQ-4, AUDIT-C) in ART clinics. Support multidisciplinary care teams to deliver coordinated interventions addressing harmful alcohol use, psychological distress, and sexual health.

- **Tailor Services to High-Risk Subgroups**
  Prioritize men, young adults (15–34 years), and socioeconomically disadvantaged populations by expanding differentiated service delivery models and community-based outreach efforts that are gender- and youth-sensitive.

- **Strengthen Healthcare Provider Capacity**
  Integrate syndemic-informed content into in-service training for HIV care providers. Develop practical tools for holistic risk assessment and syndemic-aware counseling to improve clinical decision-making and patient support.

5.2.3 Care-Level Recommendations

- **Expand Community-Based Psychosocial Support**
  Scale up peer-led and community health worker-supported psychosocial interventions to address mental health and substance use challenges, improve ART adherence, and promote viral suppression.

- **Link HIV Services to Economic Empowerment Programs**
  Strengthen collaboration between HIV care programs and existing government or NGO livelihood initiatives to reduce economic vulnerabilities that hinder treatment adherence.

- **Sustain Condom Promotion and Sexual Health Education**
  Maintain continuous condom availability and promote condom negotiation skills through education campaigns, particularly targeting youth, to reduce ongoing HIV transmission risk despite the lack of direct association with viral suppression.

5.2.4 Cross-Cutting Recommendation

- **Invest in Syndemic-Focused Research and Data Use**
  Support longitudinal, qualitative, and mixed-methods research using latent class and syndemic modeling approaches to deepen understanding of risk profiles among PLHIV. Use these findings to inform more precise program targeting and adaptive policy development.

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ANNEXES

Annex Table A 1: Unadjusted Logistic Regression: Exposure & VL Non-Suppression

Variable	Odds Ratio	Std. Error	Lower 95% CI	Upper 95% CI	P-value
Alcohol use					
(Intercept)	0.07	0.15	0.05	0.09	<0.001***
Low-risk (Ref: Abstinent)	1.59	0.29	0.89	2.82	0.114
Harmful	2.31	0.30	1.29	4.16	0.005**
Condom use					
(Intercept)	0.07	0.20	0.05	0.10	<0.001***
No condom (Ref: Condom used)	1.37	0.26	0.83	2.28	0.220
Psychological distress					
(Intercept)	0.07	0.15	0.05	0.10	<0.001***
Distressed (Ref: Not distressed)	1.66	0.24	1.03	2.67	0.038*

Annex Table B 1: Adjusted Logistic Regression: Alcohol & VL Non-Suppression

Variable	Odds Ratio	Std. Error	Lower 95% CI	Upper 95% CI	P-value	Sig.
(Intercept)	0.01	0.67	0.00	0.05	<0.001	***
Alcohol use (exposure)						
Reference: Abstinent						
Low-risk	1.79	0.34	0.92	3.47	0.085	.
Harmful	2.63	0.34	1.34	5.14	0.005	**
Age group						
Reference: 55+						
45–54	1.25	0.58	0.39	3.98	0.701	
35–44	3.28	0.50	1.23	8.77	0.018	*
25–34	5.22	0.47	2.05	13.31	<0.001	***
15–24	8.48	0.64	2.40	30.02	0.001	**
Gender						
Reference: Female						
Male	1.09	0.32	0.58	2.04	0.788	
Marital status						
Reference: Married/cohabiting						
Formerly married	0.97	0.28	0.55	1.70	0.907	
Never married	0.44	0.61	0.13	1.48	0.185	
Education						
Reference: Secondary+						
Primary	0.69	0.34	0.35	1.36	0.277	
No education	0.79	0.48	0.31	2.04	0.623	
Wealth quintile						
Reference: Highest						
Fourth	2.28	0.48	0.88	5.88	0.088	.
Middle	1.60	0.53	0.56	4.59	0.376	
Second	2.15	0.50	0.80	5.76	0.128	
Lowest	4.93	0.51	1.79	13.59	0.002	**
Region						
Reference: Very high HIV prevalence (≥7%)						
High HIV prevalence (6–6.9%)	0.68	0.35	0.34	1.35	0.269	
Medium HIV prevalence (4–5.9%)	1.77	0.27	1.04	3.02	0.035	*
Low HIV prevalence (<4%)	0.96	0.45	0.39	2.34	0.928	
Residence						
Reference: Urban						
Rural	0.74	0.28	0.42	1.28	0.281	

Annex Table B 2: Adjusted Logistic Regression: Condom Use and VL Non-Suppression

Variable	Odds Ratio	Std. Error	Lower 95% CI	Upper 95% CI	P-value	Sig.
(Intercept)	0.01	0.74	0.00	0.06	<0.001	***
Condom use (exposure)						
Reference: Condom used at last sex						
No condom	1.01	0.29	0.57	1.78	0.981	
Age group						
Reference: 55+						
45–54	1.38	0.62	0.41	4.67	0.601	
35–44	3.23	0.50	1.20	8.72	0.021	*
25–34	5.60	0.50	2.10	14.89	<0.001	***
15–24	6.88	0.67	1.84	25.70	0.004	**
Gender						
Reference: Female						
Male	1.44	0.31	0.79	2.65	0.232	
Marital status						
Reference: Married/cohabiting						
Formerly married	0.98	0.30	0.54	1.79	0.949	
Never married	0.32	0.81	0.06	1.59	0.163	
Education						
Reference: Secondary+						
Primary	0.75	0.36	0.36	1.53	0.424	
No education	0.77	0.50	0.29	2.08	0.607	
Wealth quintile						
Reference: Highest						
Fourth	2.07	0.53	0.73	5.86	0.170	
Middle	1.60	0.57	0.52	4.91	0.408	
Second	2.24	0.51	0.81	6.15	0.118	
Lowest	5.44	0.53	1.90	15.53	0.002	**
Region						
Reference: Very high HIV prevalence (≥7%)						
High HIV prevalence (6–6.9%)	0.63	0.41	0.28	1.41	0.260	
Medium HIV prevalence (4–5.9%)	1.77	0.27	1.03	3.04	0.038	*
Low HIV prevalence (<4%)	1.13	0.42	0.49	2.60	0.774	
Residence						
Reference: Urban						
Rural	0.67	0.29	0.38	1.17	0.158	

Annex Table B 3: Adjusted Logistic Regression: Psychological Distress and VLNS

Variable	Odds Ratio	Std. Error	Lower 95% CI	Upper 95% CI	P-value	Sig.
(Intercept)	0.01	0.70	0.00	0.04	<0.001	***
Psychological distress (exposure)						
Reference: Not distressed						
Distressed	1.69	0.26	1.01	2.81	0.044	*
Age group						
Reference: 55+						
45–54	1.42	0.61	0.43	4.72	0.567	
35–44	3.83	0.51	1.41	10.42	0.009	**
25–34	6.27	0.50	2.35	16.74	<0.001	***
15–24	10.31	0.62	3.05	34.86	<0.001	***
Gender						
Reference: Female						
Male	1.48	0.30	0.82	2.68	0.192	
Marital status						
Reference: Married/cohabiting						
Formerly married	1.04	0.28	0.60	1.80	0.879	
Never married	0.44	0.61	0.13	1.45	0.174	
Education						
Reference: Secondary+						
Primary	0.71	0.35	0.36	1.42	0.330	
No education	0.80	0.46	0.32	2.00	0.635	
Wealth quintile						
Reference: Highest						
Fourth	2.05	0.47	0.81	5.21	0.128	
Middle	1.46	0.54	0.50	4.24	0.487	
Second	2.01	0.49	0.76	5.32	0.160	
Lowest	4.71	0.51	1.72	12.85	0.003	**
Region						
Reference: Very high HIV prevalence (≥7%)						
High HIV prevalence (6–6.9%)	0.68	0.35	0.34	1.35	0.269	
Medium HIV prevalence (4–5.9%)	1.65	0.26	1.00	2.75	0.051	.
Low HIV prevalence (<4%)	0.98	0.43	0.42	2.29	0.964	
Residence						
Reference: Urban						
Rural	0.75	0.28	0.44	1.30	0.303	

Annex Table C 1: Logistic Regression: Latent Class and VLNS

Variable / Category	Odds Ratio	Std. Error	Lower 95% CI	Upper 95% CI	P-value	Sig.
Intercept	0.01	0.70	0.00	0.06	<0.001	***
Latent Class						
Reference (Lower Risk Class)	Ref.					
Higher Risk Class	2.48	0.34	1.27	4.85	0.008	**
Gender						
Reference (Female)	Ref.					
Male	1.23	0.32	0.66	2.29	0.506	
Age group						
Reference (55+)	Ref.					
45–54	1.28	0.58	0.41	4.01	0.678	
35–44	3.10	0.49	1.19	8.10	0.023	*
25–34	5.10	0.47	2.02	12.88	<0.001	***
15–24	5.38	0.71	1.33	21.85	0.020	*
Marital status						
Reference (Married)	Ref.					
Formerly married	0.84	0.28	0.48	1.45	0.530	
Never married	0.31	0.81	0.06	1.52	0.152	
Education						
Reference (Secondary+)	Ref.					
Primary	0.71	0.37	0.34	1.47	0.356	
No education	0.74	0.51	0.27	2.01	0.551	
Wealth quintile						
Reference (Highest)	Ref.					
Fourth	2.18	0.51	0.80	5.94	0.131	
Middle	1.78	0.55	0.60	5.23	0.298	
Second	2.37	0.51	0.88	6.39	0.089	.
Lowest	5.50	0.52	2.00	15.13	0.001	**
Residence						
Reference (Urban)	Ref.					
Rural	0.64	0.29	0.36	1.14	0.132	
Region						
Reference (Very high prevalence >7%)	Ref.					
High HIV prevalence (6–6.9%)	0.64	0.41	0.29	1.41	0.270	
Medium HIV prevalence (4–5.9%)	1.86	0.29	1.06	3.27	0.032	*
Low HIV prevalence (<4%)	1.11	0.45	0.46	2.70	0.817	

Annex Table D 1: Logistic Regression: Syndemic × Gender – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	2.60	0.39	2.44	1.20	5.65	0.02	*
Gender							
Ref: Female							
Male	1.26	0.34	0.69	0.64	2.48	0.49	
Age group							
Ref: 55+							
45 54	1.28	0.58	0.43	0.41	4.05	0.67	
35 44	3.10	0.49	2.32	1.18	8.16	0.02	*
25 34	5.13	0.47	3.46	2.02	13.04	0.00	***
15 24	5.45	0.72	2.37	1.32	22.41	0.02	*
Marital status							
Ref: Married/living together							
Formerly married	0.84	0.28	-0.63	0.48	1.46	0.53	
Never married	0.31	0.80	-1.46	0.06	1.51	0.15	
Education							
Ref: Secondary+							
Primary	0.71	0.37	-0.92	0.34	1.48	0.36	
No education	0.74	0.51	-0.60	0.27	2.03	0.55	
Wealth quintile							
Ref: Highest							
Fourth	2.18	0.51	1.52	0.79	6.02	0.13	
Middle	1.78	0.55	1.04	0.60	5.30	0.30	
Second	2.38	0.51	1.70	0.87	6.51	0.09	.
Lowest	5.52	0.52	3.29	1.98	15.43	0.00	**
Residence							
Ref: Urban							
Rural	0.64	0.30	-1.50	0.36	1.15	0.14	
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6 6.9%)	0.64	0.41	-1.10	0.29	1.43	0.27	
Medium HIV prevalence (4 5.9%)	1.86	0.29	2.17	1.06	3.29	0.03	*
Low HIV prevalence (<4%)	1.11	0.46	0.22	0.45	2.73	0.83	
Interaction							
Syndemic class × Male	0.90	0.77	-0.14	0.19	4.16	0.89	

Annex Table D 2: Logistic Regression: Syndemic × Age Group – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	2.59	13.13	0.07	0.00	493,868,100,000	0.94	
Age group							
Ref: 55+							
45-54	1.19	0.65	0.27	0.33	4.34	0.79	
35-44	3.57	0.53	2.39	1.25	10.24	0.02	*
25-34	4.48	0.53	2.84	1.58	12.71	0.01	**
15-24	7.77	0.73	2.80	1.82	33.11	0.01	**
Gender							
Ref: Female							
Male	1.31	0.31	0.87	0.71	2.40	0.39	
Marital status							
Ref: Married/living together							
Formerly married	0.84	0.28	-0.65	0.48	1.44	0.52	
Never married	0.34	0.79	-1.36	0.07	1.63	0.18	
Education							
Ref: Secondary+							
Primary	0.67	0.38	-1.03	0.32	1.44	0.31	
No education	0.73	0.51	-0.61	0.27	2.01	0.54	
Wealth quintile							
Ref: Highest							
Fourth	2.28	0.51	1.61	0.83	6.27	0.11	
Middle	1.90	0.56	1.14	0.63	5.75	0.26	
Second	2.53	0.52	1.80	0.91	7.05	0.07	.
Lowest	6.20	0.52	3.48	2.20	17.49	0.00	***
Residence							
Ref: Urban							
Rural	0.61	0.29	-1.66	0.34	1.10	0.10	.
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6-6.9%)	0.64	0.42	-1.08	0.28	1.46	0.28	
Medium HIV prevalence (4-5.9%)	1.92	0.29	2.27	1.09	3.40	0.02	*
Low HIV prevalence (<4%)	1.01	0.46	0.01	0.40	2.51	0.99	
Interaction							
Syndemic class × 45-54	1.27	13.19	0.02	0.00	270,402,400,000	0.99	
Syndemic class × 35-44	0.51	13.12	-0.05	0.00	94,287,850,000	0.96	
Syndemic class × 25-34	2.26	13.15	0.06	0.00	444,466,200,000	0.95	
Syndemic class × 15-24	0.00	8.07	-1.96	0.00	1.17	0.05	.

Annex Table D 3: Logistic Regression: Syndemic × Marital Status – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	2.12	0.54	1.38	0.72	6.23	0.17	
Marital status							
Ref: Married/living together							
Formerly married	0.78	0.31	-0.81	0.42	1.44	0.42	
Never married	0.29	1.10	-1.12	0.03	2.56	0.26	
Gender							
Ref: Female							
Male	1.24	0.32	0.69	0.67	2.32	0.49	
Age group							
Ref: 55+							
45-54	1.29	0.59	0.43	0.40	4.10	0.67	
35-44	3.09	0.49	2.31	1.17	8.13	0.02	*
25-34	5.02	0.47	3.43	1.98	12.73	0.00	***
15-24	5.26	0.73	2.28	1.25	22.17	0.02	*
Education							
Ref: Secondary+							
Primary	0.71	0.37	-0.93	0.34	1.48	0.35	
No education	0.73	0.51	-0.60	0.27	2.02	0.55	
Wealth quintile							
Ref: Highest							
Fourth	2.18	0.52	1.51	0.79	6.06	0.13	
Middle	1.77	0.55	1.03	0.60	5.24	0.30	
Second	2.37	0.51	1.71	0.87	6.45	0.09	.
Lowest	5.47	0.52	3.27	1.96	15.28	0.00	**
Residence							
Ref: Urban							
Rural	0.65	0.30	-1.47	0.36	1.16	0.14	
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6-6.9%)	0.64	0.41	-1.10	0.29	1.43	0.27	
Medium HIV prevalence (4-5.9%)	1.85	0.28	2.16	1.05	3.25	0.03	*
Low HIV prevalence (<4%)	1.11	0.46	0.22	0.45	2.74	0.83	
Interaction							
Syndemic class × Formerly married	1.39	0.73	0.44	0.32	5.92	0.66	
Syndemic class × Never married	1.42	13.24	0.03	0.00	335,107,000,000	0.98	

Annex Table D 4: Logistic Regression: Syndemic × Education – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	5.37	0.63	2.67	1.55	18.67	0.01	**
Education							
Ref: Secondary+							
Primary	0.89	0.42	-0.27	0.39	2.03	0.79	
No education	1.02	0.54	0.04	0.35	2.98	0.96	
Gender							
Ref: Female							
Male	1.26	0.32	0.71	0.67	2.37	0.48	
Age group							
Ref: 55+							
45-54	1.22	0.57	0.35	0.39	3.81	0.73	
35-44	3.07	0.49	2.29	1.17	8.08	0.02	*
25-34	5.30	0.47	3.51	2.07	13.54	0.00	***
15-24	5.61	0.72	2.38	1.34	23.47	0.02	*
Marital status							
Ref: Married/living together							
Formerly married	0.85	0.28	-0.56	0.49	1.49	0.58	
Never married	0.30	0.81	-1.50	0.06	1.47	0.14	
Wealth quintile							
Ref: Highest							
Fourth	2.15	0.52	1.49	0.78	5.96	0.14	
Middle	1.70	0.55	0.96	0.57	5.07	0.34	
Second	2.29	0.50	1.65	0.85	6.20	0.10	
Lowest	5.40	0.52	3.27	1.95	14.97	0.00	**
Residence							
Ref: Urban							
Rural	0.65	0.30	-1.42	0.36	1.18	0.16	
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6-6.9%)	0.64	0.41	-1.10	0.29	1.43	0.27	
Medium HIV prevalence (4-5.9%)	1.89	0.29	2.23	1.07	3.33	0.03	*
Low HIV prevalence (<4%)	1.13	0.47	0.26	0.44	2.88	0.80	
Interaction							
Syndemic class × Primary education	0.35	0.72	-1.46	0.08	1.46	0.15	
Syndemic class × No education	0.18	2.01	-0.85	0.00	9.67	0.40	

Annex Table D 5: Logistic Regression: Syndemic × Wealth Quintile – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	5.40	0.72	2.35	1.30	22.34	0.02	*
Wealth quintile							
Ref: Highest							
Fourth	2.48	0.66	1.38	0.68	9.06	0.17	
Middle	2.32	0.65	1.29	0.64	8.46	0.20	
Second	2.91	0.63	1.69	0.83	10.19	0.09	.
Lowest	7.95	0.65	3.19	2.19	28.80	0.00	**
Gender							
Ref: Female							
Male	1.28	0.32	0.78	0.68	2.42	0.44	
Age group							
Ref: 55+							
45-54	1.24	0.59	0.36	0.39	3.98	0.72	
35-44	3.01	0.50	2.19	1.11	8.17	0.03	*
25-34	5.07	0.49	3.34	1.94	13.27	0.00	**
15-24	5.66	0.72	2.40	1.35	23.64	0.02	*
Marital status							
Ref: Married/living together							
Formerly married	0.86	0.28	-0.54	0.50	1.49	0.59	
Never married	0.28	0.82	-1.57	0.06	1.39	0.12	
Education							
Ref: Secondary+							
Primary	0.69	0.38	-0.96	0.33	1.47	0.34	
No education	0.74	0.50	-0.60	0.28	2.00	0.55	
Residence							
Ref: Urban							
Rural	0.64	0.29	-1.49	0.36	1.15	0.14	
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6-6.9%)	0.69	0.41	-0.89	0.31	1.57	0.38	
Medium HIV prevalence (4-5.9%)	1.94	0.30	2.23	1.08	3.51	0.03	*
Low HIV prevalence (<4%)	1.10	0.49	0.20	0.42	2.89	0.85	
Interaction							
Syndemic class × Fourth	0.74	1.14	-0.26	0.08	7.01	0.79	
Syndemic class × Middle	0.34	1.21	-0.88	0.03	3.81	0.38	
Syndemic class × Second	0.53	1.17	-0.55	0.05	5.31	0.58	
Syndemic class × Lowest	0.23	0.98	-1.52	0.03	1.57	0.13	

Annex Table D 6: Logistic Regression: Syndemic × Residence – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	3.94	0.49	2.77	1.48	10.49	0.01	**
Residence							
Ref: Urban							
Rural	0.74	0.32	-0.97	0.39	1.38	0.33	
Gender							
Ref: Female							
Male	1.27	0.32	0.74	0.67	2.39	0.46	
Age group							
ReSf: 55+							
45-54	1.25	0.58	0.38	0.40	3.91	0.70	
35-44	3.09	0.49	2.30	1.17	8.15	0.02	*
25-34	5.15	0.47	3.47	2.02	13.11	0.00	***
15-24	5.42	0.71	2.38	1.33	22.09	0.02	*
Marital status							
Ref: Married/living together							
Formerly married	0.84	0.28	-0.63	0.48	1.46	0.53	
Never married	0.29	0.83	-1.50	0.06	1.49	0.14	
Education							
Ref: Secondary+							
Primary	0.71	0.38	-0.91	0.34	1.49	0.36	
No education	0.73	0.51	-0.62	0.27	1.99	0.53	
Wealth quintile							
Ref: Highest							
Fourth	2.12	0.51	1.47	0.77	5.82	0.14	
Middle	1.79	0.54	1.07	0.61	5.24	0.29	
Second	2.49	0.50	1.82	0.93	6.67	0.07	.
Lowest	5.67	0.51	3.40	2.07	15.54	0.00	***
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6-6.9%)	0.64	0.40	-1.10	0.29	1.42	0.27	
Medium HIV prevalence (4-5.9%)	1.91	0.29	2.20	1.07	3.41	0.03	*
Low HIV prevalence (<4%)	1.09	0.48	0.19	0.42	2.82	0.85	
Interaction							
Syndemic class × Rural	0.44	0.69	-1.17	0.11	1.74	0.24	

Annex Table D 7: Logistic Regression: Syndemic × Region – Association with VLNS

Subgroup / Variable / Category / Term	Odds Ratio	Std. Error	z value	Lower 95% CI	Upper 95% CI	P-value	Sig.
Ref: Lower risk class							
Syndemic class	3.33	0.55	2.17	1.11	9.97	0.03	*
Region							
Ref: Very high HIV prevalence (≥7%)							
High HIV prevalence (6–6.9%)	0.69	0.47	-0.81	0.27	1.73	0.42	
Medium HIV prevalence (4–5.9%)	2.10	0.33	2.27	1.10	4.02	0.02	*
Low HIV prevalence (<4%)	1.14	0.54	0.23	0.39	3.30	0.82	
Gender							
Ref: Female							
Male	1.24	0.32	0.67	0.66	2.32	0.50	
Age group							
Ref: 55+							
45–54	1.33	0.60	0.48	0.41	4.31	0.63	
35–44	3.20	0.49	2.40	1.23	8.35	0.02	*
25–34	5.24	0.47	3.54	2.08	13.21	0.00	***
15–24	5.59	0.71	2.44	1.38	22.60	0.02	*
Marital status							
Ref: Married/living together							
Formerly married	0.85	0.28	-0.59	0.49	1.47	0.56	
Never married	0.31	0.81	-1.45	0.06	1.54	0.15	
Education							
Ref: Secondary+							
Primary	0.71	0.37	-0.93	0.34	1.48	0.35	
No education	0.73	0.51	-0.62	0.26	2.01	0.54	
Wealth quintile							
Ref: Highest							
Fourth	2.19	0.53	1.49	0.77	6.23	0.14	
Middle	1.84	0.57	1.08	0.60	5.66	0.28	
Second	2.47	0.52	1.74	0.88	6.93	0.08	.
Lowest	5.71	0.54	3.23	1.97	16.58	0.00	**
Residence							
Ref: Urban							
Rural	0.64	0.31	-1.44	0.35	1.18	0.15	
Interaction							
Syndemic class × High HIV prev (6–6.9%)	0.73	1.03	-0.30	0.10	5.65	0.77	
Syndemic class × Medium prev (4–5.9%)	0.50	0.81	-0.87	0.10	2.46	0.39	
Syndemic class × Low HIV prev (<4%)	0.84	0.77	-0.23	0.18	3.83	0.82	

Annex E 1: Data Use Approval – UPHIA Dataset (PHIA Project)

PHIA PROJECT
POPULATION-BASED HIV IMPACT ASSESSMENT
GUIDING THE GLOBAL HIV RESPONSE

We have approved your request to access files.

Your request:

Name: Opio Emmanuel Len
Email: opiolen@gmail.com
Country: Opio Emmanuel Len
Institution Name: KIT Institute, Amsst
Institution Type: University Student

Title: The Syndemic Relationship between Alcohol Use and HIV in Uganda: A Quantitative Secondary Analysis of the Uganda Population-Based HIV Impact Assessment (UPHIA) Data

Description:
I am a Ugandan public health professional conducting this study as part of my Master of Public Health (MPH) degree at the KIT Royal Tropical Institute and Vrije Universiteit (VU) Amsterdam. This research seeks to examine the relationship between alcohol use and HIV-related outcomes in Uganda, utilizing secondary data from the Uganda Population-Based HIV Impact Assessment (UPHIA) 2020-2021. The study will address the following broad research objectives, which will be refined further based on the data: 1. Examine the association between alcohol use and HIV prevalence among adults in Uganda. 2. Investigate the influence of alcohol use on HIV-related risk behaviors 3. Assess the impact of alcohol use on ART adherence, viral suppression, CD4 Count among people living with HIV. 4. Analyze sociodemographic and contextual factors (e.g., gender, education level, urban vs. rural residence) that may moderate these relationships. 5. The regional or urban-rural differences in the syndemic relationship between alcohol use and HIV prevalence in Uganda? Additionally, I will request geomasked cluster centroid data at a later stage to enable spatial analysis and map representations of region-level findings. This will help visualize geographic patterns in the relationship between alcohol use and HIV outcomes across Uganda.

Files requested

UPHIA 2020-2021 Intermediary Weights (DTA).zip

UPHIA 2020-2021 Household and Interview and Biomarker Datasets (CSV).zip

UPHIA 2020-2021 Intermediary Weights (CSV).zip

UPHIA 2020-2021 Household and Interview and Biomarker Datasets (DTA).zip

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Thank you
PHIA Data Manager
ICAP at Columbia University

GO TO THE PHIA DATASETS PAGE

PHIA Project Website

ANNEX F

KIT Institute (Masters or Short course) Participants
Declaration for Use of Generative AI (GenAI)

Please complete and submit this form as an annex on the last page of your assignment file; and not as a separate document.

Check the box that applies to your completion of this assignment:

☐ I confirm that **I have not used** any generative AI tools to complete this assignment.

☐ I confirm that **I have used** generative AI tool(s) in accordance with the **"Guidelines for the use of Generative AI for KIT Institute Master's and Short course participants".** Below, I have listed the GenAI tools used and for what specific purpose:

Generative AI tool used	Purpose of use
1.Chat GPT	Brainstorming R code troubleshooting
2. Perplexity	Brainstorming R code troubleshooting Preliminary search of references
...	