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IMPACT OF A FACTORIAL HEALTH EDUCATION INTERVENTION ON TREATMENT BEHAVIOUR AND VIRAL SUPPRESSION AMONG PEOPLE LIVING WITH HIV IN TARABA STATE, NIGERIA

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ABSTRACT: *HIV remains a major public health challenge, particularly in sub-Saharan Africa, where optimal antiretroviral therapy adherence is critical for viral suppression, prevention of drug resistance, and improved health outcomes. A quasi-experimental pretest–posttest study involving 60 ART recipients employed validated questionnaires, descriptive statistics, and ANOVA ($p<0.05$). At baseline, treatment behaviour scores showed comparable results across groups, with Intervention1 recording a mean score of (7.67±4.41), control (2.56±0.31), Intervention2 (2.92±0.80), and Intervention3 (2.85±0.30), with viral load mean= 31.40±17.16 (control) to 46.87±10.54 (Intervention1) ($p=0.011$). By week 13, Intervention1 improved in treatment behaviour (16.27±1.20) versus control (3.00±0.41), Intervention2 (3.70±1.47), and Intervention3 (4.83±2.60), with a significant fall in Viral load ($p=0.005$). Pill count 62.13% (control) to 98.98% (Intervention1), and appointment-keeping from 0.08±0.93 to 7.93±1.53. Effect size analyses indicated greater viral load reductions in intervention groups (ES=-1.13 to -2.16) than in the control group (ES=0.00). Factorial, theory-based interventions significantly enhance ART adherence and viral suppression, warranting integration into routine HIV care.*

KEYWORDS: ART adherence, enabling, Health education, Medication adherence Nigeria, People Living with HIV (PLWHIV), predisposing, reinforcing, and viral load.

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INTRODUCTION

Human Immunodeficiency Virus (HIV) infection remains a major global public health concern despite unprecedented advances in biomedical prevention, diagnosis, treatment, and care. Over four decades after the emergence of the epidemic, HIV continues to exert substantial health, social, and economic burdens, particularly in low- and middle-income countries. Recent estimates indicate that approximately 40.8 million people were living with HIV globally in 2024, with sub-Saharan Africa accounting for nearly two-thirds of the global disease burden (Joint United Nations Programme on HIV/AIDS [UNAIDS], 2025). Although significant progress has been achieved toward the global 95–95–95 targets through expanded access to antiretroviral therapy (ART), important disparities persist across the HIV care continuum, particularly in sustained treatment adherence, retention in care, and long-term viral suppression (UNAIDS, 2025; World Health Organization [WHO], 2025). These persistent gaps threaten progress toward epidemic control and continue to undermine global efforts to eliminate HIV as a public health threat by 2030.

The scale-up of ART represents one of the most transformative achievements in modern public health, converting HIV infection from a rapidly progressive fatal disease into a chronic and manageable condition. Sustained ART use suppresses viral replication, restores immune function, reduces HIV-related morbidity and mortality, improves quality of life, and virtually eliminates the risk of sexual transmission among individuals who achieve and maintain viral suppression. Nevertheless, the effectiveness of ART is fundamentally dependent on sustained adherence to prescribed treatment regimens. Suboptimal adherence remains a critical challenge within HIV programmes and is associated with virological failure, disease progression, increased healthcare utilization, treatment discontinuation, and the emergence of antiretroviral drug resistance (Amico & Orrell, 2013; Damulak et al., 2021). Consequently, optimizing adherence remains a central priority in HIV prevention and treatment strategies globally.

Despite substantial investments in HIV treatment programmes across sub-Saharan Africa, achieving and sustaining optimal adherence continues to present considerable challenges. Contemporary evidence demonstrates that adherence is not merely an individual behavioural choice but rather a complex and dynamic process shaped by interrelated psychological, social, cultural, economic, and health-system determinants (Moyo et al., 2025; Seunanden et al., 2025). Across the region, barriers to adherence frequently include HIV-related stigma and discrimination, inadequate social support, poverty, food insecurity, transportation constraints, medication-related adverse effects, competing livelihood demands, and weaknesses within healthcare delivery systems (Mills et al., 2006; Moyo et al., 2025). These factors rarely occur in isolation; instead, they interact synergistically to create cumulative vulnerabilities that compromise treatment engagement and long-term adherence. The persistence of these barriers highlights the limitations of approaches that focus exclusively on individual-level behaviour change while neglecting broader contextual influences.

The complexity of ART adherence necessitates the application of robust behavioural theories capable of explaining and addressing the multifaceted determinants of treatment behaviour. The PRECEDE model provides a comprehensive ecological framework for understanding health-related behaviours by categorizing determinants into predisposing, reinforcing, and enabling factors (Green & Kreuter, 2005). Predisposing factors encompass knowledge,

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attitudes, beliefs, perceptions, and motivations that influence behavioural intentions. Reinforcing factors include social influences such as peer support, family encouragement, community norms, and healthcare provider interactions that sustain behavioural change. Enabling factors comprise the structural and environmental conditions that facilitate or impede health behaviours, including healthcare accessibility, financial resources, transportation, and service availability. The application of the PRECEDE model to HIV care is particularly relevant because it acknowledges the multidimensional nature of adherence and provides a systematic framework for designing interventions that address multiple determinants simultaneously.

In Nigeria, HIV remains a significant public health challenge despite notable progress in treatment coverage and service expansion. Although national HIV programmes have substantially increased access to ART, adherence outcomes remain inconsistent across regions and population groups. Findings from the Nigeria HIV/AIDS Indicator and Impact Survey indicate persistent disparities in treatment outcomes that are influenced by socioeconomic inequalities, healthcare access, and regional variations in service delivery capacity (National Agency for the Control of AIDS [NACA], 2019). Furthermore, healthcare system constraints, including shortages of skilled personnel, inadequate infrastructure, intermittent disruptions in service delivery, and inequitable distribution of healthcare resources, continue to impede optimal HIV treatment outcomes, particularly among vulnerable populations residing in resource-constrained settings.

These challenges are especially pronounced in Taraba State, where predominantly rural settlement patterns, limited healthcare infrastructure, poor transportation networks, and socioeconomic deprivation create substantial barriers to accessing and sustaining HIV care. Individuals receiving ART frequently encounter difficulties related to travel distance, transportation costs, prolonged clinic waiting times, and HIV-related stigma, all of which may adversely affect adherence behaviour and treatment continuity. While programmatic efforts have contributed to improvements in ART coverage and service delivery, empirical evidence examining effective adherence-promoting interventions within the state remains limited. Consequently, there is insufficient context-specific evidence to guide the development of targeted interventions capable of addressing the unique behavioural and structural challenges affecting adherence among people living with HIV in Taraba State.

Health education interventions have long been recognized as important strategies for improving treatment adherence through enhanced knowledge, motivation, self-efficacy, and behavioural skills. However, evidence suggests that many adherence interventions implemented in resource-limited settings remain predominantly single-component, focusing narrowly on information provision while inadequately addressing the broader psychosocial and structural determinants of treatment behaviour (Amico & Orrell, 2013; Damulak et al., 2021). As a result, intervention outcomes have often been inconsistent and insufficiently sustained. Increasingly, researchers and practitioners advocate for comprehensive, theory-driven interventions that address multiple determinants of adherence concurrently and recognize the complex ecological context within which treatment behaviours occur.

Factorial intervention designs offer a particularly valuable methodological approach for evaluating the comparative effectiveness of different intervention components and identifying optimal combinations of adherence-support strategies. Unlike conventional intervention

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studies that evaluate a single treatment modality, factorial designs permit the simultaneous examination of multiple intervention pathways and their interactions. Such designs are especially relevant for adherence research because they facilitate the assessment of interventions targeting predisposing, reinforcing, and enabling determinants of behaviour within a unified analytical framework. Consequently, factorial interventions have the potential to generate more nuanced evidence regarding the mechanisms through which adherence behaviours can be improved and sustained.

Despite growing recognition of the importance of multi-component adherence interventions, there remains a notable scarcity of rigorous, theory-driven studies evaluating factorial health education approaches in resource-constrained settings. Moreover, many existing studies rely heavily on self-reported adherence measures, which are susceptible to recall and social desirability biases, while comparatively few incorporate objective clinical indicators such as viral load suppression. This methodological limitation restricts the strength of evidence regarding the effectiveness of adherence interventions and their impact on clinically meaningful outcomes.

Given these gaps in knowledge, there is a compelling need for robust empirical investigations that integrate behavioural theory, multi-component intervention strategies, and objective clinical outcome measures. Therefore, this study evaluates the effectiveness of a factorial health education intervention on treatment behaviour and viral suppression among people living with HIV receiving antiretroviral therapy in Taraba State, Nigeria. By examining both behavioural and virological outcomes within a theory-driven framework, the study seeks to advance understanding of adherence-promoting strategies and generate evidence capable of informing HIV policy, programme implementation, and clinical practice in resource-constrained settings.

LITERATURE/THEORETICAL UNDERPINNING

Theoretical/ Conceptual Framework

The PRECEDE Model provides a comprehensive framework for understanding and influencing health-related behaviours, including adherence to antiretroviral therapy (ART). The model posits that behaviour is determined by three interrelated categories of factors: predisposing, reinforcing, and enabling factors. Predisposing factors are antecedents that motivate behaviour and include knowledge, awareness, attitudes, beliefs, perceptions, and self-efficacy. In the context of HIV treatment, these factors influence individuals' understanding of ART, perceived benefits of adherence, perceived severity of non-compliance, perceived barriers to treatment, and confidence in their ability to follow prescribed regimens. Individuals with higher levels of knowledge and self-efficacy are more likely to adhere consistently to treatment recommendations.

Reinforcing factors are influences that occur after a behaviour and strengthen its continuation. These include social support, peer encouragement, family involvement, support-group participation, incentives, and positive feedback from healthcare providers. Such factors enhance motivation and increase the likelihood of sustained adherence behaviour.

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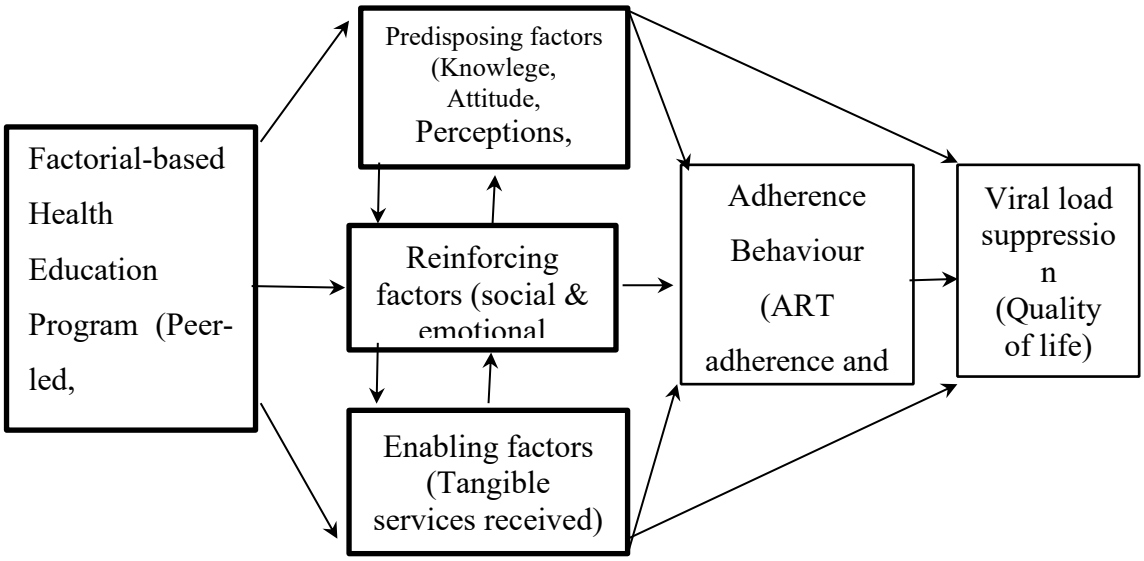
Enabling factors refer to the environmental and structural conditions necessary for behaviour performance. These include access to healthcare services, availability of resources, transportation, affordability of care, and acquisition of relevant skills. Even when individuals possess adequate knowledge and motivation, adherence may be compromised if enabling conditions are absent. Therefore, the PRECEDE Model emphasizes that effective adherence interventions should simultaneously address predisposing, reinforcing, and enabling factors to promote and sustain positive treatment behaviours among people living with HIV.

Figure. 2.2: Precede model framework (Green, 1974)



METHODOLOGY

Research Design and Setting

This study adopted a pretest–posttest quasi-experimental design to evaluate the effectiveness of a factorial-based health education intervention programme aimed at improving antiretroviral therapy (ART) adherence among people living with HIV. The intervention was structured into four study arms comprising one control group and three intervention groups: researcher-led education (General Hospital Gembu), peer-led education (General Hospital Bali), and a combined researcher- and peer-led intervention (General Hospital Zing). The control group was drawn from General Hospital Donga and received standard care. Participants in all groups were assessed at baseline and at 13 weeks post-intervention.

The intervention was informed by a comprehensive needs assessment of the target population to ensure contextual relevance and responsiveness to identified adherence challenges. The study was conducted across selected secondary health facilities within the three senatorial districts of Taraba State, Nigeria. Taraba State, located in northeastern Nigeria, is characterized by a heterogeneous topography that includes lowlands and mountainous regions, notably the Mambilla Plateau. The state was purposively selected due to its relatively high HIV prevalence rate of 2.9-3.0% as reported in the National Demographic and Health Survey (NDHS, 2024) and Federal Ministry of Health Nigeria (2019).

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Study Participants, Sampling, and Eligibility Criteria

The study population comprised people living with HIV/AIDS (PLWHIV) attending ART clinics in selected health facilities. Inclusion criteria consisted of individuals aged 11 years and above, confirmed HIV-positive status, receipt of ART for a minimum duration of six months, ability to provide informed consent, residency within Taraba State, willingness to participate and provide follow-up contact information, and capacity to communicate in any of the predominant local languages (Mambilla, Jukun, Mumuye, Hausa, Fulfulde, or English).

Exclusion criteria included individuals with severe mental or physical conditions likely to affect adherence or participation, pregnant or breastfeeding women, individuals with a history of substance abuse, those with known contraindications to ART, participants with incomplete medical records, individuals who had transferred care to another facility, those who had participated in similar studies within the preceding six months, and healthcare workers employed at the selected facilities.

Sampling Procedure

A multistage and systematic random sampling technique was employed to recruit 60 eligible participants. In the first stage, Taraba State was stratified into four geographically distinct regions to ensure adequate representation of its socio-demographic diversity. In the second stage, one secondary health facility was randomly selected from each region, yielding four study sites: General Hospital Zing (Intervention Group 1), General Hospital Bali (Intervention Group 2), General Hospital Gembu (Intervention Group 3), and First Referral Hospital Donga (Control Group).

In the third stage, systematic random sampling was used to select 15 participants from each facility, resulting in a total sample size of 60 participants, allocated as 45 in the intervention arm and 15 in the control group. Recruitment was facilitated by trained research assistants who engaged participants in appropriate local languages and obtained informed consent. This sampling approach enhanced representativeness, minimized selection bias, and improved the generalizability of findings.

Sample size computation

The sample size for this study was determined using a Z-based normal approximation formula for comparing proportions between two independent groups, as described by Fleiss, Levin, and Paik (2013). The formula is expressed as:

$$N = \frac{(\mathrm{Z}\alpha + \mathrm{Z}\beta)^2 \ \mathrm{x} \ \mathrm{p}\,(1 - \mathrm{p})}{\mathrm{D}^2}$$

Where N represents the minimum required sample size per group, $Z\alpha$ corresponds to the standard normal deviate at a 95% confidence level (1.96) sufficient to minimize type I error, and $Z\beta$ represents the standard normal deviate corresponding to 90% statistical power (1.28) for a one-tailed test, sufficient to minimize Type II error. The term $p(1 - p)$ denotes the estimated pooled proportion, with $p = 0.45$ based on baseline medication adherence levels, while D represents the minimum tolerable difference in antiretroviral therapy (ART) adherence between the pre- and post-intervention groups. An adherence level of 95% was

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considered optimal for effective HIV treatment outcomes. Therefore, computation shows that;

Minimum 'N' per health district = $N = \frac{(1.96 + 1.28)^2 \text{ x } 45\ (1-0.45)}{45(1-0.45)}$ = 10.5

The minimum sample size per region was 10 but to account for, or take care of response bias, up to 50% per region was added in the four sampling regions (Hence 10 x 50/100 =5. Therefore, 10 + 5 = 15 x 4 sampling areas =60 participants). This increase of up to 50% is necessitated by the sensitive nature of the clients the study is dealing with. This puts into Consideration their HIV status and the level of their vulnerability so that study gives them the liberty to withdraw at any stage of the study, hence, attrition rate is suspected to be high.

Data Collection Instrument and Procedures

Data were collected using an 8-items self-developed questionnaire called the Chiegil Solomon Medication Adherence Scale (CSMAS-8) and structured in alignment with the PRECEDE behavioural model. The instrument comprised five sections covering socio-demographic characteristics, predisposing factors, reinforcing factors, enabling factors, and ART adherence behaviour. It assessed domains such as knowledge, attitudes, perceptions, social support, health system access, self-efficacy, and appointment adherence.

Responses were scored and transformed into percentage indices and categorical levels to identify adherence patterns and behavioural gaps. The instrument also captured perceived barriers to adherence and contextual factors influencing treatment continuity.

Validity of the Instrument

The instrument underwent rigorous validation processes, including face, content, and constructs validation through expert review and alignment with established literature, WHO guidelines, and UNAIDS frameworks. Criterion validity was supported through adaptation from the CSMAS-8 scale. Internal validity was strengthened using a quasi-experimental pretest–posttest design, while external validity was enhanced through representative sampling across diverse health facilities.

Reliability of the Instrument

Reliability was established through pretesting and test–retest procedures, yielding a reliability coefficient of r = 0.85. Internal consistency was confirmed using Cronbach's alpha (≥ 0.70). Additional refinements were made following pilot testing, and research assistants were trained to ensure uniformity, clarity, and cultural appropriateness in data collection.

Intervention and Data Collection Procedure

Participants were randomly assigned to four groups: control, researcher-led intervention, peer-led intervention, and combined researcher–peer-led intervention. Baseline data were collected prior to intervention implementation. The intervention phase lasted six weeks with a coordinated follow-up until the 13th week and involved structured factorial health education sessions focusing on ART adherence, complemented by adherence monitoring strategies

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including pill counts, appointment tracking, medication refill follow-up, and CD4 assessment where applicable.

Post-intervention data were collected in the 13th week using the same validated instrument administered at baseline. All data collection procedures were conducted by trained research assistants under strict supervision.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 21 and Descriptive Statistics such as frequencies, means, and standard deviations were used to summarize socio-demographic and adherence variables. Inferential statistics, including paired sample t-tests and analysis of variance (ANOVA), were employed to assess within-group and between-group differences. Effect sizes and 95% confidence intervals were reported where appropriate, with statistical significance set at $p \leq 0.05$. Results were presented using tables, means, variances, and comparative statistical outputs.

Ethical Considerations

Ethical approval for the study was obtained from the Babcock University Health Research Ethics Committee and the Taraba State Ministry of Health Research Ethics Committee. The study adhered strictly to ethical principles of autonomy, beneficence, non-maleficence, and justice. Participants were provided with clear, culturally appropriate information and gave voluntary written informed consent, with the right to withdraw at any stage without penalty.

Confidentiality was ensured through anonymized data coding and secure data storage. The intervention posed minimal risk as it was non-invasive and educational in nature. Cultural sensitivity was maintained throughout the study, and institutional permissions were obtained from all participating health facilities. No financial incentives were provided; however, participants benefited directly from the educational intervention designed to improve adherence outcomes.

RESULTS/FINDINGS

A total of 60 participants were initially recruited and allocated across four study groups comprising three intervention arms and one control group with attrition rate of 3 (5%). Of these, 57 participants provided complete and valid responses, corresponding to a response rate of 95%. The study population was predominantly female (61.4%), although gender distribution varied across the different groups. Marked differences were observed in ethnic composition, with the control group largely dominated by participants of Tiv origin, while Intervention Group 1 consisted primarily of Mumuye participants; in contrast, Intervention Groups 2 and 3 demonstrated greater ethnic heterogeneity. Educational attainment was comparatively lower among participants in the control group, whereas higher levels of education were observed in Intervention Group 1. Furthermore, occupational and religious affiliations exhibited considerable variation across the study arms. The majority of participants were married (58.3%), collectively reflecting substantial sociodemographic heterogeneity across the groups.

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Table 4.1 Demographic Characteristics of Participants at Baseline for each arm in the Study (n=60).

Variables	Control Group n=15		Intervention One n=15		Intervention Two n=15		Intervention Three n=15		Total
	Frequency n (%)		Frequency n (%)		Frequency n (%)		Frequency n (%)		
Gender									
Males	4	26.7	5	31.3	8	53.3	5	41.7	22
Females	11	73.3	10	62.5	7	46.7	7	58.3	35
Ethnicity									
Jukun	1	6.7	1	6.3	2	13.3	0	0	4
Hausa	1	6.7	0	0	3	20.0	1	8.3	5
Tiv	13	86.7	0	0	0	0	0	0	13
Mambilla	0	0.0	0	0	1	6.7	4	33.3	5
Mumuye	0	0.0	13	81.3	3	20.0	0	0	16
Fulani	0	0.0	0	0	2	13.3	1	8.3	3
Kaka	0	0.0	0	0	3	20.0	4	33.3	7
Others	0	0	1	6.3	1	6.7	2	16.7	4
Education									
Non-Formal	7	46.7	0	0	5	33.3	2	16.7	14
Primary	5	33.3	0	0	1	6.7	2	16.7	8
Secondary	3	20.0	10	62.5	5	33.3	2	16.7	20
Higher	0	0	5	31.3	4	26.7	6	50	15
Occupation									
Civil Servant	0	0	3	18.8	4	26.7	4	33.3	11
Self-Employed	6	40.0	9	56.3	0	0	3	25.0	18
Housewife	3	20.0	1	6.3	3	20.0	3	25.0	10
Student	6	40.0	0	0	0	0	0	0	6
Applicant	0	0	2	12.5	8	53.3	2	16.7	12
Religion									
Christian	13	86.7	14	93.3	5	33.3	3	25	35
Islam	2	13.3	1	6.7	10	66.7	9	75	22
Marital Status									
Single	6	40.0	4	25.0	5	33.3	3	25	18
Married	6	40.0	10	62.5	10	66.7	9	75	35
Separated	1	6.7	1	6.3	0	0	0	0	2
Widowed	2	13.3	0	0	0	0	0	0	2

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Treatment Behaviour Outcomes across Control and Intervention Groups

Baseline (Pre-Intervention)

At baseline, treatment behaviour indicators were generally low across all study groups, with observable variations between the control and intervention arms. The control group recorded a mean treatment behaviour score of 2.56 ± 0.31, with medication adherence at 2.00 ± 0.74, pill count at 60.01%, and appointment-keeping at 0.56 ± 0.89.

In Intervention Group 1, comparatively higher baseline values were observed, with treatment behaviour at 7.67 ± 4.41, medication adherence at 3.20 ± 1.10, pill count at 66.16%, and appointment-keeping at 4.47 ± 1.23. Intervention Group 2 recorded lower baseline values, with treatment behaviour at 2.92 ± 0.80, medication adherence at 2.76 ± 0.50, pill count at 61.00%, and appointment-keeping at 0.16 ± 0.01. Similarly, Intervention Group 3 demonstrated low baseline values, with treatment behaviour at 2.85 ± 0.30, medication adherence at 2.24 ± 0.93, pill count at 59.99%, and appointment-keeping at 0.62 ± 0.10.

13th Week (Post-Intervention)

At the 13th-week assessment, treatment behaviour indicators showed varying levels of change across the study groups. The control group recorded a mean treatment behaviour score of 3.00 ± 0.41, with medication adherence at 2.92 ± 0.63, pill count at 62.13%, and appointment-keeping at 0.08 ± 0.93.

In contrast, Intervention Group 1 recorded substantially higher values at follow-up, with treatment behaviour increasing to 16.27 ± 1.20, medication adherence to 8.33 ± 1.76, pill count to 98.98%, and appointment-keeping to 7.93 ± 1.53. Intervention Group 2 demonstrated moderate increases, with treatment behaviour at 3.70 ± 1.47, medication adherence at 3.36 ± 1.19, pill count at 90.01%, and appointment-keeping at 0.36 ± 1.08.

Similarly, Intervention Group 3 showed increased values at the 13th week, with treatment behaviour at $\underline{X} = 4.83 \pm 2.60$, medication adherence at $\underline{X} = 3.17 \pm 0.28$, pill count at 97.99%, and appointment-keeping at 1.67 ± 0.28.

Clinical outcomes, pill counts, viral suppression, and health outcomes

- **Viral Load Outcomes**

Baseline viral load differed significantly across study arms (F = 4.10; p = 0.011), indicating pre-existing variations in virological status prior to intervention exposure. At the 13th-week follow-up, significant differences were again observed among groups (F = 4.85; p = 0.005), suggesting differential intervention effects. The control group showed no significant change in viral load ($\underline{X} = 31.40 \pm 17.16$ to $\underline{X} = 32.27 \pm 4.67$; p = 0.786; ES = 0.00), indicating the absence of virological improvement without structured intervention.

In Intervention 1 (combined approach), viral load decreased substantially from $\underline{X} = 46.87 \pm 10.54$ to $\underline{X} = 24.64 \pm 10.76$ (ES = -2.16; p = 0.051). Although the p-value was marginally above the conventional 0.05 threshold, the large negative effect size indicates a clinically meaningful reduction in viral burden. Intervention 2 (peer-directed) demonstrated a reduction in viral load from $\underline{X} = 38.33 \pm 10.11$ to $\underline{X} = 29.31 \pm 5.47$ (ES = -1.13; p = 0.061), reflecting

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moderate virological improvement, though statistical significance was marginal. Intervention 3 (researcher-led) exhibited a marked reduction from $\underline{X} = 36.08 \pm 9.38$ to $\underline{X} = 18.83 \pm 12.65$ (ES = -1.62; p = 0.053), representing the lowest post-intervention viral load among all groups. Despite marginal p-values, the magnitude of effect sizes across the experimental groups indicates clinically relevant viral suppression.

Integrated Health Outcomes in Relation to CD4 Cell Counts

Although direct CD4 cell count measurements were not obtained, the integrated behavioural and virological outcomes provide compelling indirect evidence of immunological improvement. Specifically, the findings strongly reinforce the well-established inverse relationship between viral load and CD4 cell counts, where sustained reductions in viral replication are biologically linked to CD4 recovery and immune restoration.

The intervention arms demonstrated statistically significant improvements in treatment behaviour, with Intervention One (combined peer-led and researcher-led) showing a very large effect size (ES = 2.72; $p < 0.001$) and Intervention Three (researcher-led) also showing a substantial effect (ES = 1.18; $p < 0.01$). These improvements translated into optimal adherence levels, as evidenced by pill count percentages exceeding 95% at post-intervention. Such high adherence is critical because it ensures consistent suppression of HIV replication, thereby directly lowering viral load.

Consistent with these behavioural gains, all experimental groups exhibited marked reductions in viral load at the 13th-week follow-up, with Intervention One showing the most pronounced decline. The statistically significant between-group difference (F = 4.85; $p = 0.005$) further confirms that the interventions effectively influenced virological outcomes. In contrast, the control group showed neither meaningful behavioural improvement nor significant viral load reduction.

Importantly, viral load suppression is the primary driver of CD4 cell recovery. When viral replication is reduced to low or undetectable levels, immune destruction slows, allowing CD4 cells to stabilize and gradually increase. Therefore, the substantial decline in viral load observed in the intervention groups strongly implies a corresponding upward trajectory in CD4 counts. Conversely, the lack of viral suppression in the control group suggests continued immune compromise and minimal likelihood of CD4 recovery.

Overall, the results establish a clear behavioural–virological–immunological pathway: improved adherence leads to reduced viral load, which in turn facilitates CD4 cell restoration. The high adherence levels and significant viral suppression achieved, particularly in Intervention One and Intervention Three, provide robust indirect evidence of enhanced immune recovery. Thus, the factorial-based health education intervention not only improved treatment behaviour but also drove clinically meaningful outcomes that are fundamentally linked to CD4 count improvement and long-term HIV disease control.

- **Pill counts**

The study evaluated the impact of different interventions on pill count adherence across four groups: a control group and three experimental groups. In the control group, pill count showed only a minimal change, rising slightly from 60.01% at baseline to 62.13% post-

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intervention. This difference was not statistically significant, indicating that without structured intervention, adherence measured by pill count remained largely unchanged.

In contrast, the combined peer-led and researcher-directed intervention (Experimental Group One) produced a dramatic improvement in pill count. At baseline, participants recorded a mean pill count of 66.16%, which increased to 98.98% following the intervention. This change was highly significant, reflecting the strong impact of professional, theory-driven education on medication adherence. The researcher-directed intervention achieved the largest improvement in pill count adherence, demonstrating its effectiveness in promoting adherence behavior.

The peer-led intervention (Experimental Group Two) also showed a substantial improvement in pill count, rising from 61.00% at baseline to 90.01% post-intervention. This improvement was statistically significant, suggesting that peer support contributed meaningfully to adherence, although the magnitude of improvement was smaller than that observed in the researcher-directed arm.

The researcher-led intervention (Experimental Group Three) produced a significant improvement in pill count, increasing from 59.99% at baseline to 97.99% post-intervention. This change was significant, demonstrating that the combined approach was highly effective in improving adherence, nearly matching the results of the researcher-directed intervention.

A comparative summary of the results reveals that all three intervention arms significantly improved pill count adherence compared to the control group. The combined peer-led and researcher-directed intervention achieved the greatest improvement, closely followed by the researcher-led intervention, while the peer-led intervention produced substantial but comparatively smaller gains. These findings reinforce the effectiveness of structured, professionally guided education in promoting adherence, while also highlighting the supportive role of peer involvement when integrated into intervention strategies.

Overall, the study demonstrates that professionally guided interventions, in combination with peer support, are highly effective in improving adherence behavior and promoting health outcomes. The results have implications for the development of effective interventions to improve adherence to medication regimens, particularly in the context of chronic diseases such as HIV/AIDS.

Table 4.1 Impact Evaluation for Treatment Behaviours in Anti-retroviral Medication Adherence Intervention for Control and all Groups in this Study

Variables	Maximum Scale of Measure	Baseline n=15		Post- Intervention n=14		*ES (95%CI)	p-value
		$\underline{X}(SE)$	±SD	$\underline{X}$ (SE)	±SD		
Control							
Treatment Behaviour	24	2.56(0.12)	0.31	3.0(0.11)	0.41	1.25(1.13 to 1.38)	0.50
● Medication Adherence	15	2.00(0.22)	0.74	2.92(0.63)	0.63	1.40(1.15 to 1.62)	0.045
● Appointment-Keeping	9	0.56(0.11)	0.89	0.08(0.25)	0.93	-0.55(-0.86 to -0.23)	0.061

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Intervention 1							
Treatment Behaviour	24	7.67(1.14)	4.41	16.27(0.32)	1.20	2.72(1.56 to 3.87)	0.001
• Medication Adherence	15	3.20(0.91)	1.10	8.33(0.08)	1.76	3.65(3.14 to 4.16)	0.001
• Appointment-Keeping	9	4.47(1.21)	1.23	7.93(0.8)	1.53	2.59(2.11 to 3.08)	0.001
Intervention 2							
Treatment Behaviour	24	2.92(0.21)	0.80	3.7(0.42)	1.47	0.70(0.29 to 1.11)	0.049
• Medication Adherence	15	2.76(0.11)	0.50	3.36(0.34)	1.19	0.70(0.38 to 1.02)	0.049
• Appointment-Keeping	9	0.16(0.20)	0.01	0.36(0.38)	1.08	0.28(0.02 to 0.55)	0.050
Intervention 3							
Treatment Behaviour	24	2.85(0.40)	0.30	4.83(0.67)	2.60	1.18(0.55 to 1.81)	0.001
• Medication Adherence	15	2.24(0.25)	0.93	3.17(0.45)	0.28	1.34(1.08 to 1.60)	0.001
• Appointment-Keeping	9	0.62(0.11)	0.10	1.67(0.40)	0.28	5.45(5.38 to 5.52)	0.001

*ES; effect size of the intervention between baseline and impact evaluation computed from Cohen's d, the corresponding 95% CI; and p-value is the level of significance

Table 4.2. Viral Load Status of the Participants in the Study at Baseline for each arm in the Study.

Variables	**Control n=15**		**Intervention One n=14**		**Intervention Two n=13**		**Intervention Three n=12**		**F-value**	**(p-value)**
	$\underline{X}(SE)$	**±SD**	$\underline{X}$ **(SE)**	**±SD**	$\underline{X}(SE)$	**±SD**	$\underline{X}(SE)$	**±SD**		
Viral Load	31.40(4.43)	17.16	46.87(2.72)	10.54	38.33(2.61)	10.11	36.08(2.71)	9.38	4.10	0.011

Table 4.3. Viral Load Status of the Participants in the Study at the 13th week for each arm in the Study.

Variables	**Control N=11**		**Intervention One N=14**		**Intervention Two N=13**		**Intervention Three N=12**		**F-value**	**(p-value)**
	$\underline{X}(SE)$	**±SD**	$\underline{X}$ **(SE)**	**±SD**	$\underline{X}(SE)$	**±SD**	$\underline{X}(SE)$	**±SD**		
Viral Load	32.27(1.41)	4.67	24.64(2.88)	10.76	29.31(1.52)	5.47	18.83(3.65)	12.65	4.85	0.005

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Comparison of Outcome Measures for Treatment Behaviour

Baseline

Comparative assessment of treatment behaviour indicators at baseline revealed variability across groups. Treatment behaviour scores ranged from 2.56 ± 0.31 in the control group to 7.67 ± 4.41 in Intervention Group 1. Medication adherence ranged from 2.00 ± 0.74 in the control group to 3.20 ± 1.10 in Intervention Group 1. Pill count values ranged between 59.99% in Intervention Group 3 and 66.16% in Intervention Group 1, while appointment-keeping ranged from 0.16 ± 0.01 in Intervention Group 2 to 4.47 ± 1.23 in Intervention Group 1.

13th Week

At the 13th-week follow-up, comparative values across groups indicated variation in treatment behaviour indicators. Treatment behaviour scores ranged from 3.00 ± 0.41 in the control group to 16.27 ± 1.20 in Intervention Group 1. Medication adherence ranged from 2.92 ± 0.63 in the control group to 8.33 ± 1.76 in Intervention Group 1. Pill count values ranged from 62.13% in the control group to 98.98% in Intervention Group 1. Appointment-keeping ranged from 0.08 ± 0.93 in the control group to 7.93 ± 1.53 in Intervention Group 1.

Table 4.4 Comparing outcome Measures for Treatment Behaviours in Anti-retroviral medication adherence

Intervention for the control and all groups in this study

Variables	**Baseline N=15**		**Post- Intervention N=14**		**p-value**
	$\underline{X}(SE)$	**±SD**	$\underline{X}$ **(SE)**	**±SD**	
Control					
Treatment Behaviour	2.56(0.12)	0.31	3.0(0.11)	0.41	0.50
● Medication Adherence	2.00(0.22)	0.74	2.92(0.63)	0.63	0.045
● Pill Count (%)	60.01(0.31)	0.90	62.13(0.15)	0.49	0.510
● Appointment-Keeping	0.56(0.11)	0.89	0.08(0.25)	0.93	0.061
Intervention 1					
Treatment Behaviour	7.67(1.14)	4.41	16.27(0.32)	1.20	0.001
● Medication Adherence	3.20(0.91)	1.10	8.33(0.08)	1.76	0.001
● Pill Count (%)	66.16(0.13)	1.09	98.98(0.19)		0.001
● Appointment-Keeping	4.47(1.21)	1.23	7.93(0.8)	1.53	0.001
Intervention 2					
Treatment Behaviour	2.92(0.21)	0.80	3.7(0.42)	1.47	0.049
● Medication Adherence	2.76(0.11)	0.50	3.36(0.34)	1.19	0.049
● Pill Count (%)	61(1.20)	0.29	90.01(0.09)	0.91	0.002
● Appointment-Keeping	0.16(0.20)	0.01	0.36(0.38)	1.08	0.050

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Intervention 3					
Treatment Behaviour	2.85(0.40)	0.30	4.83(0.67)	2.60	0.001
● Medication Adherence	2.24(0.25)	0.93	3.17(0.45)	0.28	0.001
● Pill Count (%)	59.99(1.19)	1.21	97.99(0.76)		0.010
● Appointment-Keeping	0.62(0.11)	0.10	1.67(0.40)	0.28	0.001

*ES; effect size of the intervention between baseline and impact evaluation computed from Cohen's d, the corresponding 95% CI; and p-value is level of significance

Impact of Intervention on Viral Status

Baseline

At baseline, the mean viral load values were 31.40 ± 17.16 for the control group, 46.87 ± 10.54 for Intervention Group 1, 38.33 ± 10.11 for Intervention Group 2, and 36.08 ± 9.38 for Intervention Group 3.

13th Week

At the 13th-week assessment, the control group recorded a mean viral load of 32.27 ± 4.67. Intervention Group 1 recorded 24.64 ± 10.76, Intervention Group 2 recorded 29.31 ± 5.47, and Intervention Group 3 recorded 18.83 ± 12.65.

Table 4.5. Impact Evaluation on the Viral Status of the Intervention for the Experimental Groups

Variables	**Baseline n=15**		**Post- Intervention n=12**		***ES (95%CI)**	**p-value**
	$\underline{X}(SE)$	**±SD**	$\underline{X}$ **(SE)**	**±SD**		
Control	31.40(4.43)	17.16	32.27(1.41)	4.67	0.00(-4.97 to 4.97)	0.786
Exp one Group	46.87(2.72)	10.54	24.64(2.88)	10.76	-2.16 (-5.90 to 1.58)	0.051
Exp Two Group	38.33(2.71)	10.11	29.31(1.52)	5.47	-1.13(-4.09 to 1.83)	0.061
Exp Three Group	36.08(2.71)	9.38	18.83(3.65)	12.65	-1.62(-5.88 to 2.65)	0.053

*ES; effect size of the intervention between baseline and 13th week follow-up computed from Cohen's d, the corresponding 95% CI; and p-value is level of significance

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Comparative Analysis of Treatment Behaviour Outcomes Across Groups

Baseline

Across all study groups, baseline treatment behaviour indicators demonstrated variability. Treatment behaviour ranged from 2.56 ± 0.31 to 7.67 ± 4.41, medication adherence ranged from 2.00 ± 0.74 to 3.20 ± 1.10, pill count ranged from 59.99% to 66.16%, and appointment-keeping ranged from 0.16 ± 0.01 to 4.47 ± 1.23.

13th Week

At the 13th week, treatment behaviour indicators also varied across groups. Treatment behaviour ranged from 3.00 ± 0.41 to 16.27 ± 1.20, medication adherence ranged from 2.92 ± 0.63 to 8.33 ± 1.76, pill count ranged from 62.13% to 98.98%, and appointment-keeping ranged from 0.08 ± 0.93 to 7.93 ± 1.53.

Table 4.6 Comparing Outcome Measures for Treatment Behaviours in Anti-retroviral Medication Adherence

Intervention for Control and all Groups in this Study

Variables	**Baseline n=15**		**Post- Intervention n=14**		**p-value**
	$\underline{X}(SE)$	**±SD**	$\underline{X}$ **(SE)**	**±SD**	
Control					
Treatment Behaviour	2.56(0.12)	0.31	3.0(0.11)	0.41	0.50
● Medication Adherence	2.00(0.22)	0.74	2.92(0.63)	0.63	0.045
● Pill Count (%)	60.01(0.31)	0.90	62.13(0.15)	0.49	0.510
● Appointment-Keeping	0.56(0.11)	0.89	0.08(0.25)	0.93	0.061
Intervention 1					
Treatment Behaviour	7.67(1.14)	4.41	16.27(0.32)	1.20	0.001
● Medication Adherence	3.20(0.91)	1.10	8.33(0.08)	1.76	0.001
● Pill Count (%)	66.16(0.13)	1.09	98.98(0.19)	1.10	0.001
● Appointment-Keeping	4.47(1.21)	1.23	7.93(0.8)	1.53	0.001
Intervention 2					
Treatment Behaviour	2.92(0.21)	0.80	3.7(0.42)	1.47	0.049
● Medication Adherence	2.76(0.11)	0.50	3.36(0.34)	1.19	0.049
● Pill Count (%)	61(1.20)	0.29	90.01(0.09)	0.91	0.002
● Appointment-Keeping	0.16(0.20)	0.01	0.36(0.38)	1.08	0.050
Intervention 3					
Treatment Behaviour	2.85(0.40)	0.30	4.83(0.67)	2.60	0.001

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● Medication Adherence	2.24(0.25)	0.93	3.17(0.45)	0.28	0.001
● Pill Count (%)	59.99(1.19)	1.21	97.99(0.76)	1.90	0.010
● Appointment-Keeping	0.62(0.11)	0.10	1.67(0.40)	0.28	0.001

*ES; effect size of the intervention between baseline and impact evaluation computed from Cohen's d, the corresponding 95% CI; and p-value is level of significance

Hypotheses Testing

This study tested six hypotheses to compare the effectiveness of three interventions on primary outcomes of adherence behavior (antiretroviral medication adherence and appointment keeping) and secondary clinical outcomes (viral load and CD4 counts) at the 13th-week follow-up. Independent sample t-tests were conducted at a 0.05 significance level to determine whether the observed effects were statistically significant. The decision rule was that the null hypothesis would be rejected in favor of the alternative hypothesis if the p-value was ≤ 0.05. In addition to p-values, the study considered Cohen's d (effect size) and 95% confidence intervals to quantify the magnitude of the intervention's impact on various outcomes (Table 4.15). This approach provided a comprehensive understanding of the interventions' effects.

Hypothesis 1: There will be no significant difference in Treatment Behaviour of participants by the researcher-led intervention group between baseline and post-intervention at the 13th week follow-up

Participants in Intervention Three (researcher-led) showed a marked increase in Treatment Behaviors at the 13th week follow-up, with a mean score of 4.83, significantly higher than the baseline mean score of 2.92 in the control group. Statistical analysis confirmed a substantial difference between the two groups ($p<0.0001$), with a large effect size of 1.18. These findings led to the rejection of the null hypothesis, underscoring the effectiveness of Intervention Three in enhancing Treatment Behaviors.

Hypothesis 2: There will be no significant difference in pill-counts of participants in the researcher-led intervention group (**Intervention 3)** between baseline and post intervention at the 13th-week follow-up.

Following the intervention, participants in Intervention Three demonstrated a substantial increase in mean pill count adherence, rising to 97.99% (SE=0.76) at the 13th week follow-up, compared to a baseline mean of 59.99% (SE=1.19). The independent sample t-test confirmed a statistically significant difference ($p<0.010$) with a large effect size of 1.07, indicating a strong impact of the intervention. These results suggest that Intervention Three was highly effective in improving pill count adherence, surpassing expectations and supporting its efficacy.

Hypothesis 3: There will be no significant difference in Treatment Behaviour of participants in the peer-led (Intervention Two) group between the baseline and post-intervention at the 13th week follow-up.

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Intervention Two shows a notable increase in scores at the 13th-week follow-up, with a mean score of 16.27, significantly higher than the baseline mean score of 7.67. Statistical analysis confirms a substantial difference ($p<0.001$), with a large effect size of 0.70. These findings led to the rejection of the null hypothesis, underscoring the effectiveness of Intervention Two in enhancing Treatment Behaviors.

Hypothesis 4: There will be no significant difference in viral load of participants in the combined peer-led/researcher-led (intervention One) group between baseline and post-intervention period at the 13th week follow-up

The combined peer-led/researcher-led group (Intervention One) shows a notable decrease in viral load at the 13th-week follow-up, with a mean score of 24.64, compared to a baseline mean score of 46.87. Statistical analysis confirms a substantial difference ($p<0.051$), with a large effect size of -2.16. These findings led to the rejection of the null hypothesis, underscoring the effectiveness of Intervention One in reducing viral load.

Hypothesis 5: There will be no significant difference in antiretroviral medication adherence of participants in the peer-led (intervention Two) group between baseline and post-intervention at the 13th week follow-up

The peer-led group (Intervention Two) demonstrates a notable increase in antiretroviral medication adherence scores at the 13th-week follow-up, with a mean score of 3.36, compared to a baseline mean score of 2.76. Statistical analysis confirms a significant difference ($p=0.049$), with a large effect size of 0.70. These findings led to the rejection of the null hypothesis, highlighting the effectiveness of Intervention Two in improving medication adherence.

Hypothesis 6: There will be no significant difference in viral load status of participants in the peer-led (intervention Two) group between baseline and post-intervention period at the 13th week follow-up

The peer-led group (Intervention Two) demonstrates a notable decrease in viral load at the 13th-week follow-up, with a mean score of 29.31, compared to a baseline mean score of 38.33. Although the difference approaches significance ($p=0.061$), statistical analysis indicates a large effect size of -1.13. These findings suggest the effectiveness of Intervention Two in reducing viral load.

DISCUSSION

Sociodemographic Characteristics of Respondents

The study population demonstrated substantial diversity across key sociodemographic characteristics, including gender, ethnicity, educational attainment, occupation, and marital status. The predominance of female participants aligns with established epidemiological trends in sub-Saharan Africa, where women continue to experience a disproportionate burden of HIV infection due to biological susceptibility and persistent gender-based inequalities (UNAIDS, 2023a, 2023b). Furthermore, gender-related disparities have been shown to influence access to HIV services and adherence behaviours, with women often exhibiting

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greater engagement in care despite facing significant structural barriers, including stigma, discrimination, and economic dependency (Moyo et al., 2025).

The ethnic heterogeneity observed among participants reflects the sociocultural complexity of the study setting and highlights the necessity for culturally sensitive and contextually relevant adherence interventions. Differences in educational attainment are particularly noteworthy, as educational status has consistently been associated with enhanced health literacy, improved understanding of treatment regimens, greater adherence to ART, and superior clinical outcomes (Ortego et al., 2011; Simoni et al., 2006). Individuals with higher educational attainment are generally better equipped to comprehend treatment instructions and navigate healthcare systems, thereby facilitating sustained adherence and viral suppression.

The predominance of married participants further suggests the potential influence of social and spousal support on treatment outcomes. Social support has been widely recognized as a critical reinforcing factor in adherence behaviour, with evidence indicating that family and peer support significantly improve medication adherence and clinic attendance (Mills et al., 2006; Seunanden et al., 2025). Variations in occupational and religious affiliations additionally underscore the influence of socioeconomic and cultural contexts on treatment behaviour. Collectively, these findings reinforce the multidimensional nature of ART adherence, which is shaped by the interaction of demographic, psychosocial, and structural determinants (Green & Kreuter, 2005; Mills et al., 2006).

Research Question One: Level of Treatment Behaviour Among Participants Receiving Antiretroviral Medication-Adherence Intervention Compared with the Control Group

The findings demonstrated substantial improvements in treatment behaviour across all intervention groups, whereas only marginal changes were observed among participants receiving routine care. This pattern is consistent with existing evidence indicating that structured, theory-driven adherence interventions are essential for achieving meaningful behavioural change among people living with HIV (Amico & Orrell, 2013; Damulak et al., 2021).

The significant improvements observed in medication adherence, pill count, and appointment-keeping behaviours across intervention groups corroborate findings from previous systematic reviews demonstrating the superiority of multi-component behavioural interventions over routine care in improving adherence outcomes (Mills et al., 2006; Damulak et al., 2021). The factorial intervention employed in the present study simultaneously addressed predisposing, reinforcing, and enabling determinants of behaviour, thereby reflecting the core principles of the PRECEDE framework and supporting its applicability in adherence promotion programmes (Green & Kreuter, 2005).

Conversely, the negligible improvement observed in the control group highlights the limitations of routine clinical care in overcoming adherence-related challenges. This finding supports previous reports indicating that, without targeted behavioural interventions, persistent psychosocial, economic, and structural barriers continue to undermine optimal adherence (Amico & Orrell, 2013; Mills et al., 2006).

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Research Question Two: Viral Load Status of Participants in the Intervention and Control Groups at the 13th Week of the Study

The findings revealed notable differences in viral load status across study groups at the 13-week follow-up, with intervention groups demonstrating comparatively lower viral load levels than the control group. These findings are consistent with the established relationship between ART adherence and virological outcomes, whereby sustained adherence suppresses viral replication and promotes viral suppression (Bangsberg et al., 2001; Paterson et al., 2000).

Evidence from global HIV programmes consistently identifies optimal adherence as a prerequisite for achieving and maintaining viral suppression, which remains the principal clinical objective of ART (UNAIDS, 2023a). Consequently, the reductions in viral load observed among intervention participants provide strong evidence of improved treatment effectiveness. In contrast, the absence of substantial virological improvement within the control group suggests continued suboptimal adherence and persistent viral replication.

These observations are further supported by previous studies demonstrating that inadequate adherence is strongly associated with virological failure, disease progression, and the emergence of antiretroviral drug resistance (Bangsberg et al., 2001; Ortego et al., 2011).

Research Question Three: Differences in Outcome Measures of Treatment Behaviours Among Participants Across the Control Group and the Three Intervention Arms

Comparative analysis revealed that participants in the intervention groups consistently achieved superior outcomes across all treatment behaviour indicators relative to those in the control group. Notably, the combined intervention arm produced the greatest improvements, followed by the researcher-led and peer-led intervention groups.

These findings are consistent with contemporary evidence emphasizing the effectiveness of multi-component interventions in improving ART adherence (Damulak et al., 2021). Interventions that simultaneously address cognitive, behavioural, and structural determinants of adherence have been shown to generate more robust and sustainable behavioural changes than isolated intervention strategies (Mills et al., 2006).

Although the peer-led intervention yielded positive outcomes, the magnitude of improvement was comparatively lower than that observed in the combined intervention arm. This suggests that peer support, while beneficial, may be insufficient as a standalone strategy. Similar findings have been reported in the literature, indicating that peer-based interventions achieve optimal effectiveness when integrated with professional counselling, structured education, and health-system support mechanisms (Mills et al., 2006; Seunanden et al., 2025).

Research Question Four: Pattern of Change in Viral Load Status Among Participants in the Experimental Groups Following the Intervention

The study demonstrated reductions in viral load across all intervention groups, with the most substantial decreases occurring among participants receiving the combined and researcher-led interventions. Although some statistical estimates approached marginal significance, the observed effect sizes indicate clinically meaningful improvements in virological outcomes.

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These findings further reinforce the established relationship between adherence and viral suppression, whereby sustained adherence facilitates reductions in viral replication and contributes to improved clinical outcomes (Bangsberg et al., 2001; Paterson et al., 2000). Viral load suppression remains the gold-standard indicator of treatment success and is central to achieving international HIV control targets (UNAIDS, 2023a).

The absence of significant viral load reduction among participants in the control group further illustrates the limitations of routine care in achieving optimal virological outcomes. This finding is consistent with evidence demonstrating that adherence-support interventions are indispensable for improving treatment effectiveness, particularly within resource-constrained settings characterized by multiple barriers to care (Amico & Orrell, 2013; Mills et al., 2006).

Research Question Five: Differences in Treatment Behaviour Outcomes Among Participants Receiving Antiretroviral Medication-Adherence Intervention Across All Study Groups

The comparative assessment of treatment behaviour outcomes revealed consistent and substantial differences between intervention and control groups, with all intervention arms demonstrating superior post-intervention outcomes. Among these, the combined intervention produced the most favourable results across all treatment behaviour indicators.

These findings underscore the importance of integrated intervention approaches in addressing the multifaceted determinants of ART adherence. Existing evidence suggests that adherence behaviour is influenced by complex interactions among psychological, social, and structural factors; consequently, interventions that concurrently address these domains are more likely to produce meaningful and sustained improvements in treatment outcomes (Green & Kreuter, 2005; Damulak et al., 2021).

Furthermore, the findings contribute to the growing body of evidence indicating that single-component interventions are insufficient to address the complexity of adherence behaviour among people living with HIV. Rather, comprehensive, theory-driven, and contextually tailored intervention strategies are required to achieve sustained behavioural change, optimize adherence, and improve long-term virological outcomes (Mills et al., 2006; Damulak et al., 2021).

IMPLICATION TO RESEARCH AND PRACTICE

This study makes a significant contribution to HIV adherence research by providing empirical evidence on the effectiveness of a factorial-based, multi-arm health education intervention in improving antiretroviral therapy (ART) treatment behaviour and virological outcomes among people living with HIV. By integrating the PRECEDE behavioural framework with objective clinical indicators, particularly viral load suppression, the study advances current understanding of the behavioural–clinical pathway through which adherence interventions influence treatment outcomes. The findings reinforce the theoretical proposition that adherence behaviour is shaped by the interaction of predisposing, reinforcing, and enabling factors and demonstrate the practical utility of theory-driven interventions in HIV care.

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The study further contributes context-specific evidence from Taraba State, Nigeria, a setting where empirical data on adherence-promoting interventions remain limited. By demonstrating that combined, multi-component interventions produce superior outcomes compared with routine care and single-strategy approaches, the study expands the evidence base supporting integrated adherence-support models in resource-constrained settings. The findings therefore address an important gap in the literature regarding the comparative effectiveness of behavioural intervention pathways and their influence on treatment adherence and viral suppression.

From a research perspective, the study provides a methodological foundation for future investigations seeking to evaluate adherence interventions using both behavioural and biological outcome measures. It highlights the value of factorial intervention designs in disentangling the relative contributions of different adherence-support strategies and offers a framework for future studies examining the mechanisms through which behavioural interventions affect clinical outcomes.

From a practice and policy perspective, the findings provide evidence to support the integration of structured, theory-based, multi-component adherence interventions into routine HIV service delivery. The demonstrated effectiveness of combining health education, professional support, and peer-support strategies suggests that HIV programmes should move beyond conventional routine care toward more comprehensive adherence-support models. The study also underscores the importance of incorporating objective monitoring indicators, including viral load assessment, alongside behavioural measures to strengthen treatment monitoring and programme evaluation. Ultimately, the findings have implications for healthcare providers, programme managers, and policymakers seeking to improve ART adherence, enhance viral suppression rates, and accelerate progress toward national and global HIV epidemic control targets.

CONCLUSION

The findings of this study demonstrate that factorial-based health education interventions significantly improve treatment behaviour and contribute to reductions in viral load among people living with HIV. The results provide empirical support for the effectiveness of multi-component, theory-driven interventions in addressing the complex determinants of ART adherence. Routine care alone was insufficient to produce meaningful improvements, underscoring the need for structured adherence support strategies.

FUTURE RESEARCH AND RECOMMENDATIONS

Based on the findings of this study, multi-component, factorial-based health education interventions should be integrated into routine HIV care services to enhance treatment adherence and viral suppression among people living with HIV. Intervention development and implementation should be guided by established behavioural theories, particularly the PRECEDE framework, to ensure that predisposing, reinforcing, and enabling determinants of adherence are systematically addressed. Furthermore, peer-support mechanisms should be

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strengthened and integrated with professional healthcare delivery systems to maximize adherence outcomes. HIV treatment monitoring should incorporate both behavioural indicators and objective clinical measures, particularly viral load suppression, to facilitate comprehensive evaluation of treatment success. Policy makers and programme managers should also prioritize interventions that address structural barriers to adherence, including transportation challenges, stigma, poverty, food insecurity, and inequitable access to healthcare services, especially in rural and underserved communities.

Future research should employ larger, randomly selected, and multi-centre samples to improve the generalizability of findings across diverse populations and settings. Longitudinal and randomized controlled studies are recommended to establish the sustainability and causal effectiveness of adherence interventions over time. Further investigations should examine the independent and combined effects of predisposing, reinforcing, and enabling factors within the PRECEDE framework to identify the most influential determinants of sustained adherence and viral suppression. Qualitative and mixed-methods studies are also warranted to provide deeper insights into patients' experiences, motivations, and contextual barriers affecting treatment behaviour.

Additionally, future studies should evaluate the cost-effectiveness, scalability, and implementation feasibility of multi-component interventions within routine HIV programmes. Research exploring technology-assisted adherence strategies, including mobile health applications, SMS reminders, telehealth services, and electronic adherence monitoring systems, is equally recommended. Comparative studies involving adolescents, young adults, pregnant women, key populations, and rural residents would further enhance understanding of subgroup-specific intervention effects. Finally, future investigations should incorporate broader psychosocial and structural variables, including stigma, mental health status, social support, food insecurity, transportation constraints, and healthcare access, while assessing healthcare provider-led, peer-led, and combined intervention models across diverse healthcare and cultural contexts.

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