Konuralp Medical Journal

Konuralp Tıp Dergisi

2026;18(1):6-16.
https://doi.org/10.18521/ktd.1732834

e-ISSN: 1309-3878
https://dergipark.org.tr/en/pub/ktd

Research Article

Understanding the Decline of HIV Incidence: Insights from Structural Equation Modeling of Social and Biological Factors

Oluwasegun Olawale Benjamin[1], Gbenga Wilfred Akinola[1], Gloria Nnadwa Alhassan[2*]

[1] Federal University Oye-Ekiti, Department of Economics, Ekiti State, Nigeria. ror.org/02q5h6807

[2] Istanbul Gelişim University, Faculty of Health Sciences, Department of Nursing, Istanbul, Türkiye. ror.org/0188hvh39

*Corresponding author: gnalhassan@gelisim.edu.tr

Received: 06.07.2025
Revision: 02.03.2026
Accepted: 04.03.2026
Online: 24.03.2026

ABSTRACT

Aim: Nigeria ranks among the countries with a high burden of Human Immunodeficiency Virus (HIV), though national incidence and prevalence have declined in recent years. Ekiti State has consistently shown lower HIV rates compared to other regions, but the specific drivers of this perceived decline remain underexplored. This study aimed to identify the key social, behavioral, and biological factors contributing to the declining HIV incidence in Ekiti State, Nigeria, using Structural Equation Modelling (SEM).

Material and Methods: A cross-sectional survey was conducted from January to March 2023 among 448 knowledgeable informants (health professionals from state and local AIDS control agencies, medical personnel, and students). Data on perceived HIV incidence and contributing factors were collected via a structured questionnaire. Confirmatory Factor Analysis and SEM were performed using AMOS software to test hypothesized paths from latent constructs (social factors, e.g., condom promotion and education campaigns; sexual behavioral factors, e.g., reductions in concurrent partners; biological factors, e.g., antiretroviral therapy access and STI reductions) to perceived declining incidence.

Results: Social ($\beta = 0.356$, $p < 0.001$) and biological ($\beta = 0.309$, $p < 0.001$) factors were significantly associated with perceived decline in HIV incidence, while sexual behavioral factors were not ($\beta = 0.019$, $p > 0.05$). The model demonstrated good fit (CFI = 0.987, RMSEA = 0.030, $\chi^2/df = 1.389$).

Conclusion: The perceived reduction in HIV incidence in Ekiti State is primarily associated with social and biological interventions. These findings highlight the value of integrated public health approaches and support efforts toward Sustainable Development Goal 3 (Good health and well-being).

Keywords: Human immunodeficiency virüs, structural equation modeling, perceived decline, social factors, biological factors, good health and well-being.

INTRODUCTION

A significant decline in the incidence of the Human Immunodeficiency Virus (HIV), the causative agent of acquired immunodeficiency syndrome (AIDS), has been recorded in Nigeria, specifically in Ekiti state, recently. The incidence per 1,000 uninfected population in Nigeria, which stood at 1.73 per 1,000 in 2000, declined to 1.23 per 1,000 in 2007 and 0.76 per 1,000 in 2017. In 2020, HIV incidence per 1,000 uninfected population for all ages fell to 0.37 per 1,000 and further declined to 0.21 per 1,000 in 2024 (1,2). With regard to Ekiti State, the percentage of HIV-positive cases declined from 12.1% in 2004 to 7.7% in 2008. As of 2020, the incident rate was 1.7% (3,4). However, the driving forces of the declining incidence of HIV in Ekiti state remain an empirical question.

HIV has been a severe public health issue globally, with Nigeria being the home to the second-largest number of people living with HIV in the world (5-7). The virus was first diagnosed in Nigeria in 1985 and spread across the 36 states in Nigeria, primarily through unprotected sex, which accounted for over 80% of the new infections (6,8). HIV became an issue of concern in the early 2000s when 7 million HIV-positive cases were recorded in the country. However, the virus's incidence has recently started to decline. This decline in HIV incidence could lead to improved quality of life, advancing good health and well-being (SDG 3), and also increases in income, savings, and productivity. This is because the age group (15-49 years) most affected remains the engine of economic growth and development for any nation, state, or community. Given this falling HIV incidence in Ekiti State, it is essential to analyze the driving forces. This will go a long way to improving understanding of the declining incidence of HIV in Ekiti State and enable public health policymakers to develop strategies to sustain the declining incidence of HIV and achieve the Sustainable Development Goals of ending AIDS by 2030.

Existing studies have attempted to investigate the factors responsible for the decline in HIV incidence worldwide, and different contributing factors have been identified in the literature. For instance, Vandormael et al. (9), Kagaayi et al. (10), Makhema et al. (11), and Pettifor et al. (12) attributed the decrease in the incidence of HIV to social factors such as marital and urban residential status, linkage to care (that is, enrollment in HIV care after a positive test, and initiation of antiretroviral therapy), access to antiretroviral therapy, and intervention efforts that kept girls in school. Some other social factors also include HIV prevention campaigns, sexual health education, HIV counseling and testing, and free treatment and care services. Several biological determinants have been associated with declining HIV incidence, including male

Cite as: Benjamin OO, Akınola GW, Alhassan GN. Understanding the decline of HIV ıncidence: insights from structural equation modeling of social and biological factors. Konuralp Med J. 2026;18(1):6-16. doi:10.18521/ktd.1732834.

This is an open access paper distributed under the terms and conditions of the Creative Commons Attribution-NonCommercial 4.0 International License.

circumcision, universal testing, pre-exposure prophylaxis (PrEP), early antiretroviral therapy initiation, and expanded treatment coverage (10-20). Furthermore, Grilo et al. (17) and Vandormael et al. (9) reported that sexual behavioral factors, such as the use of condoms, decreases in sexual experience among adolescents, and reduced HIV prevalence in the surrounding community, contributed to the reduction in HIV incidence. This also includes a delay in the age of sex debut and a decrease in the number of sexual partners.

Additionally, the reduction in global HIV incidence has likely resulted from strategic efforts, including the 95-95-95 goals (21). The 95-95-95 targets focused on ensuring that 95 percent of the people infected with HIV know their status, 95 percent of the diagnosed cases have access to antiretroviral treatment, and 95 percent of viral suppression among the people who have already been placed on antiretroviral treatment by 2020 (22). Despite the extant literature on the factors responsible for the decrease in HIV incidence in different parts of the world, limited knowledge exists about the key determinants of HIV incidence in Ekiti State, Nigeria. Therefore, this study aimed to analyze the drivers of the declining incidence of HIV in Ekiti State, Nigeria, using structural equation modelling (SEM). SEM is suitable for analyzing complex relationships, testing theory, correcting for measurement errors, modeling latent variables, and assessing overall model fit (23). Moreover, the SEM framework handles missing data optimally and addresses non-normality and binary data easily (23). The three hypotheses tested in this study are:

H1: Social factors' latent variable contributes significantly to the declining incidence of HIV/AIDS in Ekiti State, Nigeria.

H2: Sexual behavioral factors latent variable contributes significantly to the declining incidence of HIV/AIDS in Ekiti State, Nigeria.

H3: Biological factors' latent variable contributes significantly to the declining incidence of HIV/AIDS in Ekiti State, Nigeria.

MATERIAL AND METHODS

Study design

A cross-sectional study was conducted to examine factors contributing to the declining incidence of HIV in Ekiti State, Nigeria. Between 16th January 2023 and 29th March 2023, the study administered a well-structured questionnaire to collect data from knowledgeable informants, including the staff of Ekiti State Aids Control Agency and Local Government AIDS Control Agency, medical personnel (doctors, nurses, HIV counselors, pharmacists, social workers, health care assistants, and public health officials), and medical students.

Study area

The study was conducted in Ekiti State, Nigeria. Ekiti is the 6th state in Nigeria's South West geopolitical zone, with three senatorial districts (Ekiti North, Ekiti South, and Ekiti Central), 6 federal constituencies, 26 state constituencies, 16 local government areas, and 177 electoral wards. Ekiti State is predominantly a Yoruba-speaking state dominated by civil servants.

Confounder selection

Social, sexual behavioural, and biological factors were selected a priori based on established HIV epidemiological theory (24) and existing empirical evidence (9-20). These factors were conceptualized as distinct domains, each hypothesized to be directly associated with HIV incidence. In other words, none of the factors was assumed to lie on the causal pathway of another. Social factors such as condom promotion, sexual health education, and access to prevention and care were considered to have a direct association with HIV incidence because they may influence infection risk. Sexual behavioural factors, including the number of sexual partners and condom use, may directly influence HIV incidence by determining the frequency and type of exposure to infection. Furthermore, biological factors, such as sexually transmitted infections, male circumcision status, and other markers of biological susceptibility, may also directly affect the probability of HIV acquisition per exposure. Each was modelled as a latent construct to capture its multidimensional nature and reduce measurement error. The directed acyclic graph in Figure 1 was used to formalize these assumptions and to guide confounder selection for estimating associations with HIV incidence.

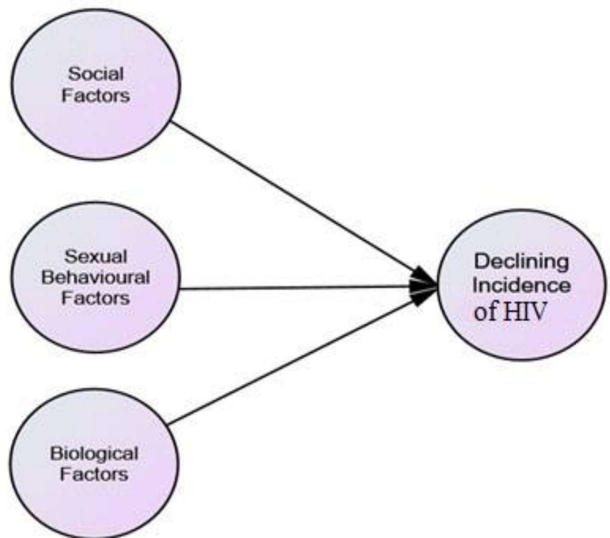


Figure 1: The directed acyclic graph of the confounders

Sampling and recruitment

The target population comprised individuals in Ekiti State who met the study's inclusion criteria. The survey was distributed via Google Forms to 602 knowledgeable informants. Of these, 448 completed the survey, yielding a response rate of 74.4%. Reasons for non-participation were not systematically collected. However, potential factors may include a lack of time, limited internet access, a lack of interest, or technical difficulties in accessing the form. The final sample of 448 respondents satisfied the observations-to-parameters ratio required for structural equation modeling, ensuring adequate statistical power and stable parameter estimation. The flow diagram in Figure 2 summarizes the sampling and recruitment procedures.

Sampling technique

A purposive sampling technique was used in this study. This enables us to focus on knowledgeable informants, including the staff of the Ekiti State Aids Control Agency (EKSACA) and the Local Government AIDS Control Agency (LACA), as well as medical personnel who can

provide the necessary information to answer the research questions. Furthermore, this technique enables us to focus on knowledgeable informants who are available and willing to participate in the research.

Statistical power

This study used the formula (25,26) developed for estimating unknown population proportions to determine the expected population size. The formula is expressed as follows:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where n is the sample size, Z represents the statistic for a level of confidence, P stands for the expected prevalence or proportion, and d is the precision. Generally, the conventional confidence interval level is always 95%, and the Z value is 1.96. The expected proportion of 30% (P = 0.3) was based on the standard deviation from the pilot study we conducted, and the precision was 5% (0.05). With a 5% margin of error and a 95% confidence interval, the study obtained a minimum sample size of 323, but 448 samples were used for the analysis. This sample size is satisfactory because it meets Kline's and Hair et al.'s minimum structural equation modeling sample size requirement of 200 (27,28). The 448 samples also exceeded the minimum observations-to-parameters ratio of 10:1, with 36 free parameters, yielding a total sample size of 360.

Inclusion and exclusion criteria

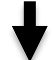
Those included in this study comprise the staff of the Ekiti State Aids Control Agency (EKSACA) and the Local Government AIDS Control Agency (LACA), medical personnel, and students with in-depth knowledge of the determinants and incidence of HIV in Ekiti State who are willing to participate. The exclusion criteria included knowledgeable informants who refused to participate in the study, and non-medical personnel not associated with EKSACA or LACA in Ekiti State.

The questionnaire

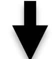
The research questions and model specification guided the design of the questionnaire. The study also used the literature on HIV and expert opinions to design the questionnaire. To avoid ambiguity and confusing questions, the questionnaire underwent multiple screening stages. The final version of the questionnaire is divided broadly into three (3) sections. The first is the demographic characteristics of respondents (7 questions), and the second is the declining incidence of HIV in Ekiti State (6 questions). The third is the factors responsible for the declining incidence of HIV in Ekiti State, and it is divided into three subsections: social factors (8 questions), sexual behavioral factors (10 questions), and biological factors (8 questions). This questionnaire is available as supplementary material. Both nominal and ordinal scales were used to code the questionnaire. The nominal scale was used for the respondents' demographic characteristics, while the ordinal scale was used for the Likert scale. The Likert scales vary from 1 to 5, with 5 denoting Strongly Agree (SA), 4 for Agree (A), 3 standing for Neutral (N), 2 representing Disagree (D), and 1 denoting Strongly Disagree (SD).

Target Population
Knowledgeable informants in Ekiti State who meet the inclusion criteria

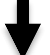
Eligible and Invited Participants
Knowledgeable informants invited via Google Forms
= 602



Non-participation
Did not complete the survey
= 154
Possible reasons: Lack of time, limited internet access, lack of interest, and technical difficulties



Completed Responses
Google Forms submissions received
= 448



Final Analytical Sample
Included in SEM analysis
= 448
Response rate = 74.4%

Figure 2. Flow diagram of sampling and recruitment

Data collection

A well-structured questionnaire was used to gather the primary data used for the analysis. The survey was conducted in all 16 local government areas in Ekiti State, Nigeria, between 16 January 2023 and 29 March 2023. Moreover, all eligible respondents who met the inclusion criterion received the questionnaire, which included a cover page explaining its purpose.

Variables

The dependent variable is the declining incidence of HIV, and it has six observed variables, but three were removed to meet the convergent validity assumption. The remaining three observed variables are Incidence 3 (Ekiti State has the lowest HIV incidence in the South West of Nigeria), Incidence 4 (The incidence of HIV/AIDS is declining in Ekiti State), and Incidence 6 (Government is making progress in sustaining the decline in HIV/AIDS incidence). Moreover, three latent or independent variables were analyzed in the study. These variables are social, sexual, and biological factors. Social factor has eight observed variables, named Social Factor 1 to Social Factor 8. Social Factors 1, 3, 4, and 7 were removed to ensure that the model met the convergent validity assumption. The remaining observed variables are Social Factor 2 (Condom promotion), Social Factor 5 (Improvement in rural HIV

education), Social Factor 6 (Improvement in sexually transmitted infections campaign), and Social Factor 8 (Legal framework against sexual violence).

The sexual factor has 10 observed variables, but the study removed SexualFactor4 and 5 because their factor loadings were less than 0.5. Moreover, SexualFactor1, 2, and 3 were deleted to satisfy the assumption of convergent validity. The relevant observed variables are SexualFactor6 (Decrease in the proportion of sexually active youth), SexualFactor7 (Decrease in concurrent sexual partners from 6 to 5), SexualFactor8 (Decrease in concurrent sexual partners from 5 to 4), SexualFactor9 (Decrease in concurrent sexual partners from 4 to 3), and SexualFactor10 (Decrease in concurrent sexual partners from 3 to 2). The third independent variable is the biological factor, which has eight observed variables. To achieve the convergent validity goal, the study excluded BiologicalFactor1 to 5, and the remaining observed factors are BiologicalFactor6 (Availability of biomedical HIV transmission facility), BiologicalFactor7 (Reduction in Sexually Transmitted Infections), and BiologicalFactor8 (Scale-up of preventive intervention targeting the key populations).

Statistical analysis

Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structure (AMOS) were used to analyze the data obtained from the participants. SPSS was used for the preliminary analyses, including data screening, descriptive statistics, and reliability testing (Cronbach's Alpha). Two major techniques (Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM)) were used for the data analysis in AMOS. CFA was used to assess model fit, construct reliability, convergent validity, and discriminant validity. Also, outliers and multicollinearity were checked. For the model fitness, different sets of indices were used. Chi-square, degrees of freedom, and p-values were used to determine the model's fitness. In addition, three indices of incremental model fit, namely the Tucker-Lewis Index (TLI), the Incremental Fit Index (IFI), and the Comparative Fit Index (CFI), were used for the analysis. Other indices, including normed fit index (NFI), Relative Fit Index (RFI), Root Mean Square Error of Approximation (RMSR), P-value of the Null Hypothesis (PCLOSE), and Standardized Root Mean Squared Error (SRMR), were also used to determine the fitness of the proposed model.

The constructs' reliability and factor loading estimates, which are expected to exceed 0.5, were used to assess convergent validity. Furthermore, the study established the discriminant validity using maximum shared variance and average variance extracted. Covariance-based SEM was used to analyze the hypothesized relationships between the dependent and independent variables. SEM was chosen because of its superiority over other mediation testing techniques (29). Also, SEM is appropriate when one exogenous (independent) variable becomes an endogenous (dependent) variable. In other words, SEM is suitable when there are several endogenous variables (30).

This study was conducted in full compliance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Ethical and Legal Review Committee (ELRC) of the Federal University Oye-Ekiti, Nigeria, with approval number ELRC/SOS/002.

All participants involved in the study provided written informed consent electronically prior to their inclusion. The research team ensured that participant confidentiality, data protection, and ethical conduct were upheld throughout the research process, in line with the university's research ethics policy.

RESULTS

Description of study participants

Table 1 presents the demographic characteristics of the 448 participants. 59.8% of the respondents were females, 40.2% were males, and 65.6% were married. The respondents in the 35-44 age group (38.6%) were the largest. 30.6% of the respondents fell in the 25-34 age group, 26.1% were between 45 and 54, and 4.7% were 55 or older. A larger percentage of the respondents (77.2%) were Christians, followed by Muslims (18.5%), and Traditionalists (4.2%) came last. About half of the respondents (48.7%) have earned a Bachelor of Medicine, Bachelor of Surgery, or equivalent; 28.1% have a degree below Bachelor of Medicine, Bachelor of Surgery; 18.3% have a master's degree or equivalent; and just 4.9% are PhD holders.

Table 1. Demographic characteristics of study participants (n = 448).

Demographic Characteristics		Frequency	Percentage
Sex	Male	180	40.2
	Female	268	59.8
Marital Status	Single	115	25.7
	Married	294	65.6
	Divorced	24	5.4
	Widowed	15	3.4
Age	25-34	137	30.6
	35-44	173	38.6
	45-54	117	26.1
	≥ 55	21	4.7
Religion	Christianity	346	77.2
	Islam	83	18.5
	Traditional	19	4.2
Education	PhD	22	4.9
	Master's or equivalent	82	18.3
	Bachelor of Medicine, Bachelor of Surgery or equivalent	218	48.7
	Below Bachelor of Medicine, Bachelor of Surgery or equivalent	126	28.1

Reliability and Validity Test Results

The results of the construct reliability and convergent validity tests, summarized in Table 2, revealed that Cronbach's Alpha exceeded 0.6 (31), Also, composite reliability and maximum reliability exceeded the threshold (0.7), and average variance extracted (except Social Factors) exceeded 0.5. Meanwhile, the study concluded that the model satisfied the convergent validity assumption since composite reliability and maximum reliability exceeded 0.6 (32). Moreover, the square roots of average variance extracted (0.674, 0.723, 0.711, 0.728) exceeded the inter-construct correlation coefficients, and the values of average variance extracted are greater than those of maximum shared variance. This confirmed that the model satisfied the discriminant validity requirements.

Table 2. Construct reliability and convergent validity

Reliability and Convergent Validity	Cronbach's Alpha	Composite Reliability >0.7	Maximum Reliability > 0.7	Average Variance Extracted
Declining Incidence	0.765	0.770	0.784	0.529
Social Factors	0.769	0.769	0.771	0.455
Sexual Behavioural Factors	0.843	0.845	0.857	0.523
Biological Factors	0.732	0.753	0.760	0.505

Discriminant Validity

	Maximum Shared Variance < Average Variance Extracted	Social Factors	Sexual Behavioural Factors	Biological Factors	Declining Incidence Social Factors
Declining Incidence Social Factors	0.449<0.455	**0.674**			
Sexual Behavioural Factors	0.382<0.523	0.512***	**0.723**		
Biological Factors	0.449<0.505	0.670***	0.618***	**0.711**	
Declining Incidence Social Factors	0.329<0.529	0.573***	0.393***	0.560***	**0.728**

Note: *** denotes significance at less than 0.001, and less than is depicted by <.

Model Fit

All indices, except the probability of Chi-square, reported in Table 3, indicated that the estimated confirmatory factor analysis is a good fit. Chi-squared is sensitive to sample size and is likely to reject accurate information (27,33). Most fit indices met recommended thresholds (Table 3).

Table 3. Model fit indices

Measure	Finding	Threshold	Source
Chi-square stat (P-value)	112.541 (0.012)	≥0.05	(34)*
Chi-square/DF	112.541/81=1.389	1≤x≤2	(35)
Normed Fit Index	0.954	≥0.9	(36)
Relative Fit Index	0.941	≥0.9	(37)
Incremental Fit Index	0.987	≥0.9	(37)
Tucker-Lewis Index	0.983	≥0.9	(36)
Comparative Fit Index	0.987	≥0.9	(36)
Root Mean Square Error of Approximation	0.030	<0.06	(38)
P-value of the Null Hypothesis	0.998	>0.05	(34)
Standardized Root Mean Squared Error	0.032	<0.08	(34)

DF: denotes the degree of freedom, and the probability of the Chi-square stat is in parenthesis.

CFA and SEM Estimates

The study conducted CFA to establish the model's fitness. Specifically, the study assessed the factor loadings, removed those below 0.5, and covaried six observed variables, as shown in Figure 3, to maintain acceptable AVE and ensure that no items cross-load. The standardized values reported in Table 4 can be likened to the regression coefficients; the critical ratio is similar to the z-statistic, and the probability (P) value is not different from the p-value of regression analysis (31). The values of the C.R. presented in Panel A of Table 4 exceeded the cut-off point of ±1.96, All factor loadings were statistically significant ($p < 0.001$), as shown in Table 4.

Table 4. CFA and SEM estimates

Panel A

Variable			Coef.	S.E.	C.R.	SMC
SF2	←	SF	0.641***			0.411
SF5	←	SF	0.650***	0.093	10.835	0.422
SF6	←	SF	0.703***	0.100	11.435	0.494
SF8	←	SF	0.702***	0.103	11.426	0.492
SBF6	←	SBF	0.663***			0.439
SBF7	←	SBF	0.702***	0.100	11.681	0.492
SBF8	←	SBF	0.836***	0.109	12.633	0.492
SBF9	←	SBF	0.700***	0.096	11.659	0.490
SBF10	←	SBF	0.704***	0.088	11.870	0.495
BF6	←	BF	0.673***			0.453
BF7	←	BF	0.770***	0.106	11.632	0.593
BF8	←	BF	0.685***	0.101	10.375	0.470
DI3	←	DI	0.653***			0.426
DI4	←	DI	0.805***	0.100	12.129	0.647
DI6	←	DI	0.718***	0.097	11.704	0.515

Panel B

Variable			Coef.	S.E.	C.R.
DI	←	SF	0.356***	0.098	3.979
DI	←	SBF	0.019	0.070	0.266
DI	←	BF	0.309***	0.097	3.067

*** and ** denoted significant at <0.001 and <0.010, respectively. Standardized regression weights (Coef.), Standard Error (S.E.), Critical Ratio (CR), Squared Multiple Correlations (SMC), Social Factors (SF), Sexual Behavioural Factors (SBF), Biological Factors (BF), and Declining Incidence (DI).

Moreover, standardized estimates of all the observed variables reported in Panel A of Table 4 (also presented in Figure 3) exceeded 0.5. Specifically, the factor loadings of the measures of social factors ranged from $\beta = 0.641$ to $\beta = 0.703$, with SF6, that is, "Improvement in sexually transmitted infections campaign," having the highest factor loading of 0.703. The factor loadings for the four measures of sexual behavior also ranged from $\beta = 0.700$ to $\beta = 0.836$. Among the four measures of sexual behavioral factors and all the observed variables in the model, SF8, which stands for "Decrease in concurrent sexual partners from 5 to 4," recorded the highest factor loading of 0.836. Moreover, factor loadings of the measures of the biological factor ranged from $\beta = 0.673$ to $\beta = 0.770$. In addition, the observed variables for the declining incidence of HIV ranged from $\beta = 0.653$ to $\beta = 0.805$, with DI4, that is, "Incidence of HIV in Ekiti State decreased in the year 2008," having the highest factor loading of 0.805. Standardized factor loadings ranged from 0.641 to 0.836 across constructs (Table 4). All standardized factor loadings for DI, SF, SBF, and BF exceeded the recommended threshold of 0.50.

The last column in Panel A summarizes the squared multiple covariances, indicating the variance of the observed variables explained by the latent constructs. This is also presented in Figure 3. Squared multiple correlations ranged from 0.41 to 0.64 across observed variables of the improvement in sexually transmitted infection campaigns (SF6), 50 percent of the variance of legal framework against sexual violence (SF8), 42 percent of the variance of rural HIV education improvement (SF5), and 41 percent of the variance of condom promotion (SF2). The respective measurement errors, e2, e5, e6, and e8, in Figure 1 account for the remaining variance. Sexual behavioral factors explained 50 percent of the variance in each observed variable. In comparison, biological factors explained the largest proportion (60 percent) of the variance in the observed variable, reduction in sexually transmitted infections (BF7). Declining incidence appeared to outperform other latent constructs, as it explained 64 percent of the variance in DI4, which is "the incidence of HIV/AIDS is declining in Ekiti State." As illustrated in Figure 1, the respective error terms explain the remaining variance in each observed variable.

Panel B of Table 4 presents the structural model estimates. Social factors were positively associated with perceived declining HIV incidence ($\beta = 0.356$, $p < 0.001$). Sexual behavioural factors showed a positive but non-significant association ($\beta = 0.019$, $p > 0.05$). Biological factors were positively associated with perceived declining HIV incidence ($\beta = 0.309$, $p < 0.001$).

Figure 3 shows the estimated structural equation model depicting the impact of social, sexual behavioral, and biological factors on the declining incidence of HIV. For clarity, the estimates are presented in Table 4. The variables in the big cycle are the latent constructs or unobserved variables, those in the rectangle are the observed variables, and the error terms are represented by the small cycle. The squared multiple correlation is 0.38. The SEM model fit indices suggested that the incidence model is of good fit.

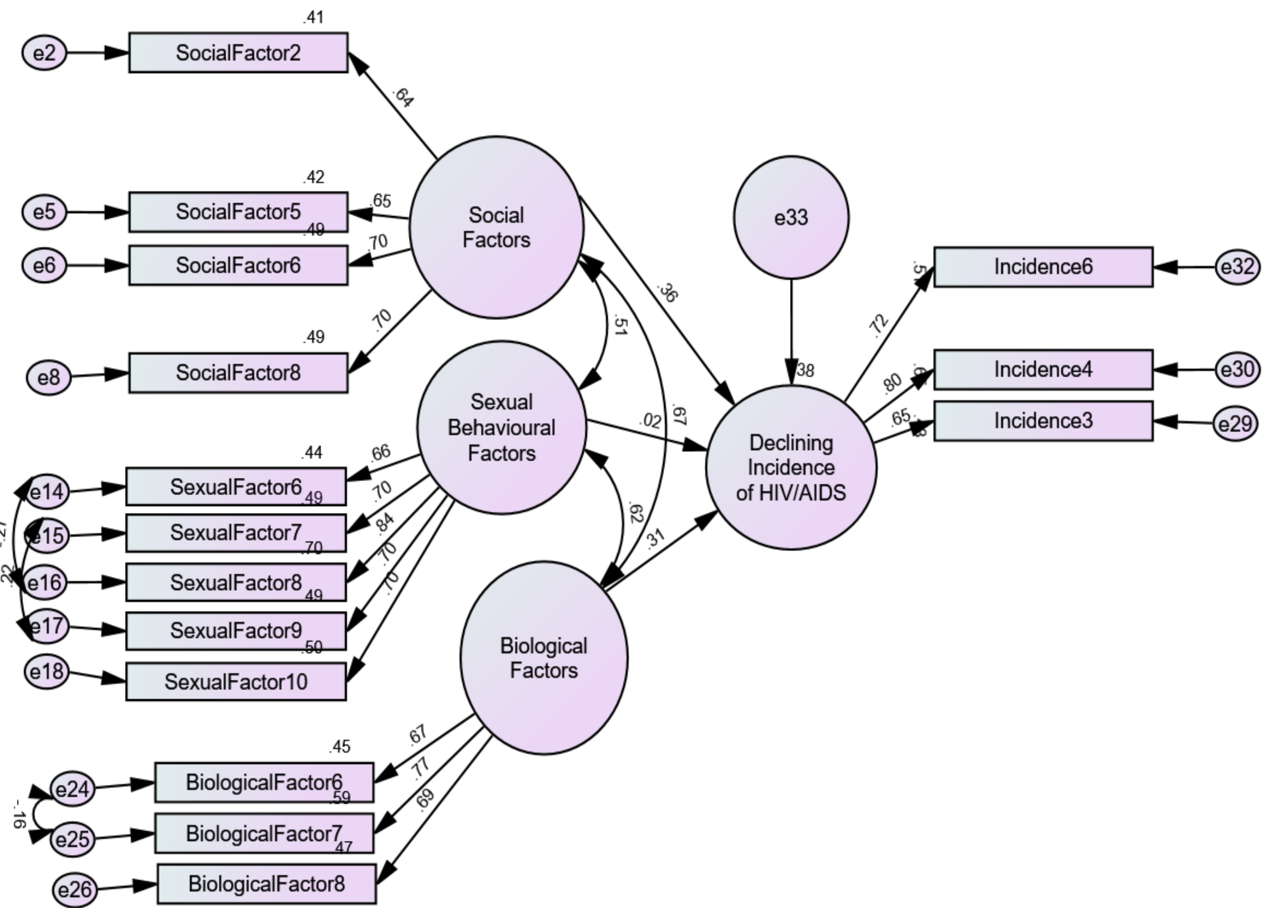


Figure 3. SEM of the declining incidence of HIV/AIDS in Ekiti State

DISCUSSION

This study analyzed the determinants of the perceived declining incidence of HIV in Ekiti State, Nigeria. The structural model indicated that social and biological factors were significantly associated with perceived reductions in HIV incidence, whereas sexual behavioural factors did not demonstrate a statistically significant association. Existing studies (1,2,4) have shown that HIV incidence is declining in Ekiti State, Nigeria, but the factors responsible for this decline have not yet been identified. The possible factors that could contribute to the decrease in HIV incidence were grouped into three latent constructs in this research: social, sexual behavioral, and biological factors. The results of the cross-sectional study showed that the four-factor loadings of the social factors analyzed in this study, namely condom promotion, improvement in rural HIV education, improvement in sexually transmitted infections campaign, and legal framework against sexual violence, were associated with perceived reduction in HIV incidence in Ekiti State. Though this empirical finding contrasts (17,39,40), it aligns with several other studies (41-45).

Specifically, condom promotion increases condom awareness and the use of condoms, which in turn eliminates the possibility of having contact with bodily fluids containing HIV during sex. Though a few studies (39,40) argued that intervention efforts, including condom promotion, do not have any plausible effect on HIV transmission, other studies (41,42) attested to the fact that condom promotion reduces the transmission of HIV.

Furthermore, improvement in rural HIV education enhances the students' knowledge of HIV transmission channels, reduces risk, and enables them to develop safer behavior attitudes and reduce exposure to HIV through sexual intercourse (43,44). Though this disagrees with the findings of Grilo et al. (17), it aligns with the submission of an existing study (12) that intervention efforts that keep girls in school reduce HIV infection. Also, it is in line with the findings of Maduakolam et al. (45), who submitted that HIV education enables students to avoid risky sexual behaviors.

Another observed variable of the social factors that were associated with perceived reduction in HIV incidence is the improvement in the campaign against sexually transmitted infections. This finding aligns with Kalichman et al. (46), who proved that improvement in sexually transmitted infections campaigns is associated with HIV transmission. Mass media and social marketing of sexually transmitted infection campaigns improve people's knowledge of HIV (47) and influence their awareness and attitudes toward HIV prevention measures. Additionally, policy and advocacy, community, school, workplace, and faith-based campaigns provide a platform for people to become more familiar with HIV transmission channels, risk factors, and prevention measures. Sexual violence raises the level of HIV susceptibility (48,49), and the elimination of such violence has been associated with a decline in HIV infection (50). Legal frameworks against sexual violence, which is the fourth observed variable of the social factors, criminalize all the recklessness that could increase HIV incidence and promote respect for human dignity.

Though sexual behavioral factors are positively associated with perceived decline in HIV incidence rates in Ekiti

State, there is insufficient evidence that the sexual behavioral factors (that is, decrease in the proportion of sexually active youth and the number of sexual partners) are associated with the perceived decrease in the incidence of HIV. This finding contrasts with the findings of researchers (9,17,51-55), who found that sexual behavioral factors, especially condom use and a decrease in sexual experience, are associated with a reduction in the incidence of HIV. However, the finding conforms with the results of Grilo et al. (17), who reported that sexual behavior factors, especially condom use and having multiple partners, did not associate with the decrease in HIV incidence in Rakai, Uganda. The lack of statistical significance of sexual behavioral factors does not imply that sexual behavior is unimportant for HIV transmission, but possibly reflects limitations in how these behaviors are measured and modeled. Also, the insignificant finding may result from the inconsistent and incorrect use of condoms or the traditional and cultural differences of the population under study. Moreover, the indicators used are self-reported, capturing only decreases in the proportion of sexually active youth and in concurrent sexual partners from 6 to 5, 5 to 4, 4 to 3, and 3 to 2. In addition, sexual behaviors are highly sensitive to social desirability and stigma, increasing the likelihood of systematic underreporting. Reported behaviors may also have different risk implications across the senatorial zones, introducing heterogeneity that weakens average associations in pooled analyses.

Moreover, the empirical findings revealed that the biological factors analyzed in this study are associated with a perceived reduction in HIV incidence in Ekiti State, Nigeria. This result is consistent with findings from the U.S. Centers for Disease Control and Prevention (15), Smith et al. (56), and Ng et al. (57), who attributed the reduction in HIV incidence to biological factors. The observed variables of this latent construct include the availability of biomedical HIV transmission facilities, reduction in sexually transmitted infections (STIs), and scaling-up of preventive intervention targeting the key populations to reduce harm. Smith et al. (56) reported that increased loads of patients at HIV clinics, especially in local areas, contribute to HIV transmission. The provision of biomedical HIV transmission and testing facilities removes barriers to adequate care, enhances accessibility to the facilities in the HIV clinics, and makes it easy to detect the virus early and start treatment (15,56). This finding lends credence to Ng et al. (57), who claimed that a decrease in HIV incidence is associated with population-based biomedical STI interventions.

Furthermore, interventions leading to the decline in STIs and the scaling-up of preventive interventions were associated with a perceived reduction in HIV incidence and decreased HIV infection in Ekiti State, Nigeria. This finding aligns with the results of some researchers (58,59). So, in addition to the social factors, Ekiti State Aids Control Agency and other government agencies focusing on making Ekiti State an HIV-free state should provide biomedical HIV transmission facilities, scale up preventive intervention targeting the key populations, and intensify efforts to reduce sexually transmitted infections in the State.

CONCLUSION

This study highlights the decline in HIV incidence in Ekiti State, Nigeria, through a cross-sectional analysis to identify the driving factors. Our findings reveal that social interventions such as condom promotion, improving rural HIV education, consistent sexually transmitted infections campaigns, and a strong legal framework against sexual violence have played a central role in decreasing HIV incidence. Additionally, the availability of biomedical facilities for HIV transmission prevention, a decrease in STIs, and the expansion of targeted preventive measures for key populations have been associated with this decline. The substantial factor loadings from the structural equation modeling support the robustness of the measurement model and provide a reliable model for policy formulation. However, recognizing the limitations of our model in capturing all potential influences on HIV trends, we emphasize the need to consider future technological advancements. The integration of digital health could be instrumental in sustaining and accelerating progress towards the 2030 sustainability goal (60).

Telemedicine services can provide essential remote care for HIV patients and at-risk individuals, ensuring continuous support, particularly in underserved rural areas. Mobile health applications can enhance HIV education, monitor treatment adherence, and offer confidential counseling services (61). Culturally sensitive community-driven digital health initiatives can create peer support networks through digital platforms. These technological evolvements emphasize the role of SDG 9: Industry, innovation, and infrastructure in supporting the public health system, while also contributing to SDG 1: No poverty by improving health outcomes, and promoting SDG 8: Decent work and economic growth through better health and productivity, aligning with Sustainable Development Goals of ending AIDS by 2030.

To evolve these technologies effectively, fostering cross-sectoral collaboration among health authorities, technology companies, non-governmental organizations, and community organizations is crucial for developing integrated HIV prevention and treatment strategies. While our insights open the way for innovative approaches to combat HIV, the future success of such programs depends on continued global funding support for low- and middle-income countries (62). Policy makers can leverage our study's findings to guide health policy development and devise strategies to help prevent the HIV epidemic in Ekiti State before 2030.

Study limitations

This study has important limitations that should be considered when interpreting the findings. First, the use of purposive sampling limits generalizability because the sample consists of knowledgeable informants rather than the general population. In addition, data were collected primarily from professionals and students, whose knowledge, perceptions, and risk profiles may differ systematically from those of the general population, further constraining external validity. Second, key variables were measured using self-reported Likert-scale items, which are susceptible to recall error, social desirability bias, and method bias. Third, the cross-sectional study design precludes causal inference, as exposure and outcome measures were assessed at the same time point. Fourth, one

latent construct exhibited marginal convergent validity, as indicated by average variance extracted values of 0.455, which is below the recommended 0.5 threshold. Finally, the outcome reflects perceived HIV incidence rather than epidemiologically confirmed incidence, meaning the results capture respondents' perceptions and interpretations of risk rather than actual population-level transmission dynamics.

DECLARATIONS

Acknowledgements: The authors do not wish to acknowledge any individual or institution.

Author Contributions: Conceptualization, O.O.B. and G.W.A.; Methodology, O.O.B. and G.N.A.; Software, O.O.B.; Validation, O.O.B. and G.N.A.; Formal Analysis, O.O.B.; Investigation, O.O.B. and G.W.A.; Resources, G.W.A.; Data Curation, O.O.B.; Writing Original Draft Preparation, O.O.B.; Writing Review & Editing, G.N.A.; Visualization, O.O.B.; Supervision, G.W.A.; Project Administration, G.W.A.; Funding Acquisition, Not applicable. All authors have read and approved the final version of the manuscript.

Conflict of Interest: We wish to disclose here that there are no potential conflicts of interest at any level of this study.

Supporting Institutions: We hereby declare that there is no form of funding received for this study.

Ethical Approval: This study was conducted in full compliance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Ethical and Legal Review Committee (ELRC) of the Federal University Oye-Ekiti, Nigeria, with approval number ELRC/SOS/002.

All participants involved in the study provided written informed consent prior to their inclusion. The research team ensured that participant confidentiality, data protection, and ethical conduct were upheld throughout the research process, in line with the university's research ethics policy.

Plagiarism Statement: This article has been evaluated for plagiarism, and no instances of plagiarism were detected.

Use of AI Tools: The authors declare that no Artificial Intelligence (AI) tools were used in the creation of this article.

REFERENCES

1. Joint United Nations Programme on HIV/AIDS (UNAIDS). Nigeria country data [Internet]. 2024 [cited 2025 Dec 25]. Available from: https://www.unaids.org/en/regionscountries/countries/nigeria
2. Joint United Nations Programme on HIV/AIDS (UNAIDS). Key results in Nigeria [Internet]. 2024 [cited 2025 Dec 25]. Available from: https://open.unaids.org/countries/nigeria
3. Ekiti State Action Committee on AIDS. HIV/AIDS Ekiti state strategic plan for action (2010-2015). 2009. Unpublished document obtained from the Ekiti State Aids Control Agency.
4. Ekiti State Action Committee on AIDS. Ekiti state HIV and AIDS strategic plan for action (2021-2025). 2021. Unpublished document obtained from the Ekiti State Aids Control Agency.
5. Salihu HM, Murtala HA, Murtala AM, Abdullahi AA, Abbas MA, Yusuf AL, et al. HIV-tuberculosis co-infection in conflict zones of Nigeria. Trop Med Int Health. 2025;30(7):625-32. doi:10.1111/tmi.14112.
6. Ali MJ, Onoja A, Shambe I, Afolaranmi T, Egbere OJ, Olorunfemi PO, et al. Prevalence of human immunodeficiency virus and selected sexually transmitted infections among female sex workers in Jos, Nigeria. Journal of Epidemiological Society of Nigeria. 2025;8(1-2):46-57. doi:10.5281/zenodo.16889829.
7. Ukaegbu E, Alibekova R, Ali S, Crape B, Issanov A. Trends of HIV/AIDS knowledge and attitudes among Nigerian women between 2007 and 2017 using Multiple Indicator Cluster Survey data. BMC Public Health. 2022;22(1):440. doi:10.1186/s12889-022-12865-y.
8. Joint United Nations Programme on HIV/AIDS. HIV and AIDS in Nigeria: 2018 UNAIDS statistics for Nigeria [Internet]. 2019 [cited 2025 December 25]. Available from: https://www.avert.org/professionals/hiv-around-world/sub-saharan-africa/nigeria
9. Vandormael A, Cuadros D, Dobra A, Bärnighausen T, Tanser F. HIV incidence declines in a rural South African population: a G-imputation approach for inference. BMC Public Health. 2020;20(1):1205. doi:10.1186/s12889-020-09193-4.
10. Kagaayi J, Chang LW, Ssempijja V, Grabowski MK, Ssekubugu R, Nakigozi G, et al. Impact of combination HIV interventions on HIV incidence in hyperendemic fishing communities in Uganda: a prospective cohort study. Lancet HIV. 2019;6(10):e680-7. doi:10.1016/S2352-3018(19)30190-0.
11. Makhema J, Wirth KE, Pretorius Holme M, Gaolathe T, Mmalane M, Kadima E, et al. Universal testing, expanded treatment, and incidence of HIV infection in Botswana. N Engl J Med. 2019;381(3):230-42. doi:10.1056/NEJMoa1812281.
12. Pettifor A, MacPhail C, Hughes JP, Selin A, Wang J, Gómez-Olivé FX, et al. The effect of a conditional cash transfer on HIV incidence in young women in rural South Africa (HPTN 068): a phase 3, randomised controlled trial. Lancet Glob Health. 2016;4(12):e978-88. doi:10.1016/S2214-109X(16)30253-4.
13. Borgdorff MW, Kwaro D, Obor D, Otieno G, Kamire V, Odongo F, et al. HIV incidence in western Kenya during scale-up of antiretroviral therapy and voluntary medical male circumcision: a population-based cohort analysis. Lancet HIV. 2018;5(5):e241-9. doi:10.1016/S2352-3018(18)30025-0.
14. Chen Y, Li AD, Yang Y, Lu J, Xu Y, Ji X, et al. Global, regional and national burden of HIV/AIDS among individuals aged 15-79 from 1990 to 2021. AIDS Res Ther. 2025;22(1):51. doi:10.1186/s12981-025-00745-5.
15. U.S. Centers for Disease Control and Prevention. HIV declines among young people and drives overall decrease in new HIV infections [Internet]. 2023 [cited 2025 December 26]. Available from: https://www.cdc.gov/media/releases/2023/p0523-hiv-declines-among-young-people.html
16. Grabowski MK, Serwadda DM, Gray RH, Nakigozi G, Kigozi G, Kagaayi J, et al. HIV prevention efforts and incidence of HIV in Uganda. N Engl J Med. 2017;377(22):2154-66. doi:10.1056/NEJMoa1702150.
17. Grilo SA, Thompson J, Chen IS, Nalugoda F, Lutalo T, Wei Y, et al. Declines in HIV incidence and prevalence and predictors among adolescents and young adults: an observational cohort study, Rakai, Uganda, 2005-2020. medRxiv [Preprint]. 2025; 2025.01.07.25320118. doi:10.1101/2025.01.07.25320118.
18. Mhlanga L, Welte A, Grebe E, Ohler L, van Cutsem G,

Huerga H, et al. Evidence of HIV incidence reduction in young women, but not in adolescent girls, in KwaZulu-Natal, South Africa. IJID Reg. 2023;8:111-7. doi:10.1016/j.ijregi.2023.07.004.
19. Hayes RJ, Donnell D, Floyd S, Mandla N, Bwalya J, Sabapathy K, et al. Effect of universal testing and treatment on HIV incidence—HPTN 071 (PopART). N Engl J Med. 2019;381(3):207-18. doi:10.1056/NEJMoa1814556.
20. McClelland RS, Richardson BA, Cherutich P, Mandaliya K, John-Stewart G, Miregwa B, et al. A 15-year study of the impact of community antiretroviral therapy coverage on HIV incidence in Kenyan female sex workers. AIDS. 2015;29(17):2279-86. doi:10.1097/QAD.0000000000000829.
21. UNAIDS. Understanding measures of progress towards the 95–95–95 HIV testing, treatment and viral suppression targets [Internet]. 2023 [cited 2025 December 23]. Available from: https://www.unaids.org/sites/default/files/media_asset/progress-towards-95-95-95_en.pdf
22. Jones J, Sullivan PS, Curran JW. Progress in the HIV epidemic: Identifying goals and measuring success. PLoS Med. 2019;16(1):e1002729. doi:10.1371/journal.pmed.1002729.
23. Alamer A. Structural equation modeling (SEM) in L2 writing research: simple tutorial and useful recommendations. Research Methods in Applied Linguistics. 2025;4(2):100202. doi:10.1016/j.rmal.2025.100202.
24. Hargreaves JR, Delany-Moretlwe S, Hallett TB, Johnson S, Kapiga S, Bhattacharjee P, et al. The HIV prevention cascade: integrating theories of epidemiological, behavioural, and social science into programme design and monitoring. Lancet HIV. 2016;3(7):e318-22. doi:10.1016/S2352-3018(16)30063-7.
25. Cochran WG. Sampling techniques. 3rd ed. New York: John Wiley & Sons; 1977.
26. Daniel WW, Cross CL. Biostatistics: a foundation for analysis in the health sciences. 11th ed. New York: John Wiley & Sons; 2018.
27. Hair Jr JF, Black WC, Babin BJ, Anderson RE. Multivariate data analysis. 7th ed. New Jersey: Prentice Hall; 2011.
28. Kline, RB. Principles and practice of structural equation modeling. 3rd ed. New York: The Guilford Press; 2011.
29. Whittle R, Mansell G, Jellema P, van der Windt D. Applying causal mediation methods to clinical trial data: what can we learn about why our interventions (don't) work? Eur J Pain. 2017;21(4):614-22. doi:10.1002/ejp.964.
30. Tabachnick BG, Fidell LS. Using multivariate statistics. 5th ed. New York: Allyn & Bacon/Pearson Education; 2007.
31. Pervan M, Curak M, Pavic Kramaric T. The influence of industry characteristics and dynamic capabilities on firms' profitability. Int J Financial Stud. 2018;6(1):4. doi:10.3390/ijfs6010004.
32. Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research. 1981;18(1):39-50. doi:10.2307/3151312.
33. Loverock A, Benny C, Smith BT, Siddiqi A, Pabayo R. Income inequality and deaths of despair risk in Canada, identifying possible mechanisms. Soc Sci Med. 2024;344:116623. doi:10.1016/j.socscimed.2024.116623.
34. Byrne, BM. Structural equation modelling with AMOS: basic concepts, applications, and programming. 3rd ed. New York: Routledge; 2016.
35. Gefen D, Straub D, Boudreau MC. Structural equation modeling and regression: guidelines for research practice. Communications of the Association for Information Systtems. 2000;4(1):7. doi:10.17705/1CAIS.00407.
36. Lei PW, Wu Q. Introduction to structural equation modeling: Issues and practical considerations. Educational Measurement: Issues and Practice. 2007;26(3):33-43. doi:10.1111/j.1745-3992.2007.00099.x.
37. Koropp C, Kellermanns FW, Grichnik D, Stanley L. Financial decision making in family firms: an adaptation of the theory of planned behavior. Family Business Review. 2014;27(4):307-27. doi:10.1177/0894486514522.
38. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Structural Equation Modeling. 1999;6(1):1-55. doi:10.1080/10705519909540118.
39. Kajubi P, Kamya MR, Kamya S, Chen S, McFarland W, Hearst N. Increasing condom use without reducing HIV risk: results of a controlled community trial in Uganda. J Acquir Immune Defic Syndr. 2005;40(1):77-82. doi:10.1097/01.qai.0000157391.63127.b2.
40. Moreno R, Nababan HY, Ota E, Wariki WM, Ezoe S, Gilmour S, et al. Structural and community-level interventions for increasing condom use to prevent the transmission of HIV and other sexually transmitted infections. Cochrane Database Syst Rev. 2014;2014(7):CD003363. doi:10.1002/14651858.CD003363.pub3.
41. Wariki WM, Ota E, Mori R, Koyanagi A, Hori N, Shibuya K. Behavioral interventions to reduce the transmission of HIV infection among sex workers and their clients in low-and middle-income countries. Cochrane Database Syst Rev. 2012;2012(2):CD005272. doi:10.1002/14651858.CD005272.pub3.
42. Kang Dufour MS, Maiorana A, Allen C, Kassie N, Thomas M, Myers J. How faith based organizations' doctrines regarding sexuality affect their participation in the public health response to HIV in the Eastern Caribbean. Sex Res Soc Policy. 2013;10(3):221-32. doi:10.1007/s13178-013-0123-8.
43. Lv BY, Xiang YX, Zhao R, Feng ZC, Liang SY, Wang YM. Impact evaluation of HIV/AIDS education in rural Henan province of China. J Huazhong Univ Sci Technolog Med Sci. 2013;33(6):905-11. doi:10.1007/s11596-013-1220-x.
44. Faust L, Yaya S. The effect of HIV educational interventions on HIV-related knowledge, condom use, and HIV incidence in sub-Saharan Africa: a systematic review and meta-analysis. BMC Public Health. 2018;18(1):1254. doi:10.1186/s12889-018-6178-y.
45. Maduakolam IO, Ogbonnaya NP, Ndubuisi IF, Ekechukwu EN, Okoronkwoa IL, Onwujekwe O. Effects of a structured health education on prevention of HIV risky behaviours among adolescents in Nigeria–a pragmatic randomized controlled trial. Libyan J. Med. 2022;17(1):2128414. doi:10.1080/19932820.2022.2128414.
46. Kalichman SC, Eaton L, Cherry C. Sexually transmitted infections and infectiousness beliefs among people living with HIV/AIDS: implications for HIV treatment as prevention. HIV Med. 2010: 11(8):502-9. doi:10.1111/j.1468-1293.2009.00818.x.
47. Stead M, Angus K, Langley T, Katikireddi SV, Hinds K, Hilton S, et al. Mass media to communicate public health messages in six health topic areas: a systematic review and other reviews of the evidence. Public Health Res. 2019;7(8). doi:10.3310/phr07080.
48. Decker MR, Crago AL, Chu SK, Sherman SG, Seshu MS, Buthelezi K, et al. Human rights violations against sex workers: burden and effect on HIV. Lancet. 2015;385(9963):186-99. doi:10.1016/S0140-6736(14)60800-X.
49. Watts CH, Foss AM, Hossain M, Zimmerman C, von Simson R, Klot J. Sexual violence and conflict in Africa: prevalence and potential impact on HIV incidence. Sex Trans infections. 2010;86(Suppl 3):iii93-9. doi:10.1136/sti.2010.044610.
50. Shannon K, Strathdee SA, Goldenberg SM, Duff P, Mwangi P, Rusakova M, et al. Global epidemiology of HIV among female sex workers: influence of structural determinants.

Lancet. 2015;385(9962):55-71. doi:10.1016/S0140-6736(14)60931-4.

51. Giannou FK, Tsiara CG, Nikolopoulos GK, Talias M, Benetou V, Kantzanou M, et al. Condom effectiveness in reducing heterosexual HIV transmission: a systematic review and meta-analysis of studies on HIV serodiscordant couples. Expert Rev Pharmacoecon Outcomes Res. 2016;16(4):489-99. doi:10.1586/14737167.2016.1102635.
52. Maheu-Giroux M, Vesga JF, Diabaté S, Alary M, Baral S, Diouf D, et al. Changing dynamics of HIV transmission in Cote d'Ivoire: modeling who acquired and transmitted infections and estimating the impact of past HIV interventions (1976–2015). J Acquir Immune Defic Syndr. 2017;75(5):517-27. doi:10.1097/QAI.0000000000001434.
53. Mukandavire Z, Mitchell KM, Vickerman P. Comparing the impact of increasing condom use or HIV pre-exposure prophylaxis (PrEP) use among female sex workers. Epidemics. 2016;14:62-70. doi:10.1016/j.epidem.2015.10.002.
54. Williams JR, Alary M, Lowndes CM, Béhanzin L, Labbé AC, Anagonou S, et al. Positive impact of increases in condom use among female sex workers and clients in a medium HIV prevalence epidemic: modelling results from Project SIDA1/2/3 in Cotonou, Benin. PLoS One. 2014;9(7):e102643. doi:10.1371/journal.pone.0102643.
55. Stover J, Teng Y. The impact of condom use on the HIV epidemic. Gates Open Res. 2022;5:91. doi:10.12688/gatesopenres.13278.
56. Smith MK, Miller WC, Liu H, Ning C, He W, Cohen MS, et al. Effects of patient load and travel distance on HIV transmission in rural China: Implications for treatment as prevention. PloS One. 2017;12(5):e0177976. doi:10.1371/journal.pone.0177976.
57. Ng BE, Butler LM, Horvath T, Rutherford GW. Population-based biomedical sexually transmitted infection control interventions for reducing HIV infection. Cochrane Database Syst Rev. 2011;(3):CD001220. doi:10.1002/14651858.CD001220.pub3.
58. Cepeda JA, Eritsyan K, Vickerman P, Lyubimova A, Shegay M, Odinokova V, et al. Potential impact of implementing and scaling up harm reduction and antiretroviral therapy on HIV prevalence and mortality and overdose deaths among people who inject drugs in two Russian cities: a modelling study. Lancet HIV. 2018;5(10):e578-87. doi:10.1016/S2352-3018(18)30168-1.
59. McCree DH, Jeffries WL 4th, Beer L, Gant Z, Elmore K, Sutton M. Exploring factors associated with declining HIV diagnoses among African American females. J Racial Ethn Health Disparities. 2018;5(3):598-604. doi:10.1007/s40615-017-0405-6.
60. Sparviero S, Ragnedda M. Towards digital sustainability: the long journey to the sustainable development goals 2030. Digital Policy, Regulation and Governance. 2021;23(3):216-28. doi:10.1108/DPRG-01-2021-0015.
61. Alhassan GN, Bosnak AS, Hamurtekin E. Perceived satisfaction and outcomes from drug information center services provided with a telehealth approach. Niger J Clin Pract. 2022;25(12):2053-61. doi:10.4103/njcp.njcp_552_22.
62. Abernethy A, Adams L, Barrett M, Bechtel C, Brennan P, Butte A, et al. The promise of digital health: then, now, and the future. NAM Perspect. 2022;2022: 10.31478/202206e. doi:10.31478/202206e.