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Evaluating the mediating effect of behavioural and biological practices in the relationship between sociostructural risk factors and HIV infection outcomes among Adolescent Girls and Young Women: a cross-sectional study in central Uganda

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Abstract

Background Adolescent Girls and Young Women (AGYW) face a heightened risk of new HIV Infections. However, research findings on the relationships between sociostructural risk factors, behavioural and biological practices, and HIV infection outcomes have been inconsistent. This study examines how behavioural and biological practices mediate the relationship between sociostructural risk factors and HIV infection outcomes among AGYW in Central Uganda.

Methods We employed a quantitative, cross-sectional study to evaluate the mediating effect of behavioural and biological practices in the relationship between sociostructural risk factors and HIV Infection outcomes. Using simple random sampling, 375 AGYW participants aged 15–24 years with unknown HIV status were selected from Masaka Hospital Maternal Child Health Department (MCH) (253) and Out-Patient Department (OPD). Modeling (SEM) analyses were used to conduct mediation effect analyses using the Statistical Package for the Social Sciences (SPSS), version 27.0.

Results Post-exposure prophylaxis (PEP) use (β = 0.242, $p = 0.000$) and the number of sexual partners (β = 0.091, $p = 0.000$) mediated the relationship between sociostructural risk factors such as alcohol consumption (β = -0.064, $p = 0.020$), marital status (β = -0.086, $p = 0.001$), exposure to sexual and gender-based violence (SGBV) (β = 0.267, $p = 0.000$), discrimination (β = 0.070, $p = 0.031$), and stigma (β = 0.092, $p = 0.038$) and HIV infection outcomes among AGYW in Central region. The most significant effect was observed in the pathway: SGBV→ PEP use →HIV infection contributing 6.5% of the total effects. There was a strong direct path from sociostructural risk factors to HIV infection

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with a factor load of 75.6%. In contrast, the indirect paths showed weaker effects: from sociostructural risk factors to biological practice with a factor load of 36.2%, and from biological practice to HIV infection with a factor load of 25.3%.

Conclusion Limiting exposure to SGBV, addressing discrimination and HIV stigma, and encouraging the use of PEP should be a priority in reducing HIV infections among AGYW aged 15–24 years in Central Uganda.

Keywords Adolescent girls, HIV infection, Risk factors, Uganda, Young women

Background

Human immunodeficiency virus (HIV) attacks cells that help the human body fight infection, making the individual more susceptible to other diseases [1]. Additionally, the HIV infection epidemic thwacks households and communities and affects the social and economic growth of societies, regions, and countries, with many suffering from food insecurity, other infectious diseases, and public health problems [1, 2]. HIV Infection is thus a major global public health challenge affecting mostly vulnerable subpopulations and societies [3, 4].

Adolescent Girls and Young Women (AGYW) in sub-Saharan Africa (SSA) are disproportionately affected by HIV [5, 6]. According to the WHO 2023 report, of the 38.4 million people living with HIV (PLHIV) globally in 2021, SSA accounted for 25.6 million, representing more than two-thirds of PLHIV worldwide [7]. In the same year, AGYW aged 15–24 years comprised 63% of all new HIV infections in SSA [2] and were twice as likely to be living with HIV compared to their male counterparts [2]. In 2022, nearly two-thirds of the 210,000 new HIV infections among AGYW worldwide were in SSA [6], making it the most affected region [7].

Among Uganda's 45.7 million people, an estimated 1.4 million live with HIV, with AGYW being the most affected group [5, 8, 9]. In 2020, the AGYW aged 15–24 years contributed 26% of the 53,000 new HIV infections and 79% of all new HIV infections among youth aged 15–24 years [8, 9], despite representing only 10% of the population [10]. The Uganda AIDS Commission (UAC) 2022–2023 Report revealed that AGYW accounted for over two-thirds of the new HIV infections in 2021 [5], with prevalence rates of 4.2% among AGYW and 2.4% among adolescent boys and young men (ABYM) [5, 8]. This highlights the pressing public health threat of HIV among AGYW in Uganda.

The disproportionate burden of HIV among AGYW is attributed to declining behavioural, biological, and sociostructural risk indicators [8, 11, 12, 13, 14]. However, research findings on the relationships between these factors and HIV infection outcomes have been inconsistent. For example, Pre-Exposure Prophylaxis (PrEP) was associated with reduced new HIV infections in Botswana [15], South Korea [16], and England [17], but the opposite was observed in Tanzania, South Africa, and Kenya [18]. Additionally, PrEP use has been linked to stigma, with AGYW who reported stigma being reluctant to use PrEP and facing adherence challenges, leading to an increased risk of HIV infections [19]. Early sexual debut among young women in Malawi, Guinea, Swaziland, and Cameroon [20] has been reported as a significant predictor of early marriages and increased HIV risk. In contrast, delaying sexual debut has helped curb HIV infections in Kenya [21]. Relatedly, early marriage was associated with increased new HIV infections in Kenya [22] and Zimbabwe [23] but not in Lesotho, Guinea, and Cameroon [24].

It remains unclear how sociostructural risk factors directly or indirectly affect behavioural and biological practices and HIV infection outcomes among the AGYW aged 15–24 years in Uganda's Central region [5, 25, 26]. These outcomes can vary by geographical context [27–29]. AGYW in different countries of SSA face unique HIV risk challenges, including early marriages, gender-based violence, stigma, and limited access to education and healthcare [12, 27, 30–32]. Therefore, country-specific knowledge is needed to address age-gender inequalities in HIV infection risk reduction [20].

Understanding the mediating effect of behavioural and biological practices on the relationship between sociostructural risk factors and HIV infection outcomes among AGYW in central Uganda is necessary for the development and implementation of targeted interventions to limit the spread of HIV infection in this vulnerable population. Therefore, this study aimed to examine the mediating effect of behavioural and biological practices on the relationship between sociostructural risk factors and HIV infection outcomes among AGYW in central Uganda.

Methods

Study aim, design, and setting

This cross-sectional study aimed to evaluate the mediating effect of behavioural and biological practices on the relationship between sociostructural risk factors and HIV infection outcomes. Transparent and complete reporting for this study was guided by STrengthening the Reporting of OBservational Studies in Epidemiology (STROBE) statement [33]. The authors fulfilled the twenty two checklist items before submitting the manuscript.

The serosurvey was conducted between March to May 2023 among AGYW in Central Uganda, a region purposely chosen due to its high HIV prevalence of 10.4%

compared to the national prevalence rate of 5.4% [34]. Central Uganda covers an area of 61,403.2 km^2 with a population of 9,529,227 [10].

Masaka Regional Referral Hospital was randomly chosen as the study location. The hospital's catchment area includes eight of the twenty-four districts constituting the Central region [35], with a total population of 1,583,991, of which 29.4% are AGYW. The specific district populations are Masaka (297,004), Rakai (276,746), Lyantonde (93,753), Lwengo (274,953), Sembabule (252,597), Bukomansimbi (151,413), Kalungu (183,232), and Kalangala (54,293) [10].

Participant characteristics and data collection procedures

AGYW aged 15–24 years with unknown HIV status, residing in the study districts of Masaka, Lwengo, Sembabule, Lyantonde, Bukomansimbi, Kalungu, Rakai, and Kalangala, and attending Masaka Hospital's MCH and OPD departments, were included in the study upon providing written informed consent or assent and parent/guardian approval for those under 18. The study sample size was computed using the general rule of thumb for logistic regression with a precision of 5% [36]. The initial sample size of 300 was increased by 20% to account for potential dropout [37], resulting in a final desired sample size of 375. We enrolled 122 and 253 participants from the Masaka Hospital OPD and MCH departments, respectively, based on the proportional average quarterly attendance of AGYW in each department [38], with about 30 AGYW receiving care at each department daily. Simple random sampling was used by assigning random numbers to potential respondents in the clinic waiting area on each recruitment day.

The research participants completed the interview process in period of 45 min to one hour including the consenting process and responding to the questionnaire. They received 10,000 Uganda shillings financial benefit as time compensation for participating in the study as recommended by a recent research [39]. The respondents helped to provide information necessary to contextually refine and determine how to design more effective sets of HIV interventions at multiple levels of social organization in Central region, Uganda.

Data quality control and assurance was performed through several methods. Data on behavioural and biological practices, sociostructural risk factors, and HIV test results among AGYW were collected using a structured questionnaire adapted from the HIV/AIDS Tool Kit [40], the 2016 Uganda Demographic and Health Survey [34], and the 2011 Uganda AIDS Indicator Survey [41]. We piloted the questionnaire among 20 AGYW aged 15–24 years at a non-participating facility to evaluate the tool's appropriateness, acceptance, and validity. It was revised until the content validity index reached 0.877, exceeding the minimum recommended index of 0.7 for survey studies [42]. The questionnaire, comprising 73 items with a Cronbach's alpha of 0.790, was considered reliable and was used to assess the study variables [42, 43].

The questionnaire was administered through face-to-face interviews by three trained research assistants, who were two females, a social worker, and an enrolled nurse, and one male who was an enrolled nurse. All the research assistants had three years past experience in conducting HIV related research, in the study area. Before participating in research activities, the research assistants underwent a three-day training conducted by the researcher, I.M, on the study scope and procedures, including consent administration and data collection for the study. The research assistants were fluent in English and Luganda. Data collection was conducted in either Luganda or English language depending on the participant's preference, ensuring privacy and confidentiality within the health facility.

Eligible AGYW who participated in the interviews were asked to voluntarily provide a blood sample for HIV testing, which was conducted using standard testing and quality-control procedures established by Uganda's Ministry of Health [44] in compliance with the WHO standards [1]. All AGYW diagnosed with HIV infection were linked to the Antiretroviral Therapy (ART) clinic on the same day for further management.

The study protocol was approved by the Clarke International University Research Ethics Committee (CLARKE-2022-453) and the Uganda National Council for Science and Technology (NCST) (HS2554ES). All participants provided written informed consent before participation, and data collection adhered to all ethical standards in healthcare research [45]. Filled questionnaires were collected by the investigator and data entered directly into SPSS version 27.0 for statistical analysis. Data cleaning was done after entry, followed by data analysis. Data editing was performed to detect errors and omissions in the collected raw data as a means of controlling the quality of data that was collected [42]. The researcher checked for completeness of the questionnaire to ensure that all survey data was collected, accurate, and well arranged to facilitate proper coding and analysis.

Study variables

The dependent variable was HIV infection, measured by the occurrence of newly diagnosed HIV infection among AGYW who tested positive. Data on HIV serostatus was recorded as either HIV positive or Negative (0 = No, and 1 = Yes). The independent variables were sociostructural risk factors such as marital status, education level, wealth status, alcohol consumption, stigma, discrimination,

laws, health policies, and access to risk-reduction services adopted from related studies [46–48]. The potential mediators were considered to be behavioural (age at first sex, number of sexual partners, condom use) and biological (HTS use, PrEP use, PEP use, STI treatment and partner circumcision) [49–52] to influence the HIV infection among AGYW.

Statistical analysis

Data was analysed using the Statistical Package for Social Sciences (SPSS) version 27.0 software. Both descriptive statistics (percentages and counts) and Structural Equation Modelling (SEM) were performed. Mediation analysis was conducted using SEM to determine the direct and indirect effect of the sociostructural risk factors, behavioural practices, and biological practices on HIV infection outcomes. Interaction terms with a p-value < 0.05 were considered statistically significant.

SEM was run using path analysis to generate the effect sizes for pathways based on hypothesized paths. The Goodness-of-fit statistics was conducted to establish the extent to which the structural model is fit to predict HIV infection outcomes using the indicators of: the Root mean squared error of approximation (RMSEA), the Standardized root mean squared residual (SRMSR), the Comparative Fit Index (CFI) and the Tucker-Lewis index (TLI). A good model-data fit is indicated by SRMR < 0.08, RMSEA < 0.06, CFI > 0.95, and TLI > 0.9 [53].

Results

Of the 375 AGYW sampled, 24 (6.4%) refused to participate in the study by not providing an informed consent. A total of 351 (93.6%) surveys were utilized for data entry and analysis as shown in Fig. 1.

Descriptive statistics

Demographic characteristics of AGYW in central Uganda

According to Table 1, most of the respondents were Catholics 52.7% (185), followed by Anglicans 22.2% (78), and Moslems 21.4% (75). The majority, 97.4% (342), of the participants were Ugandan nationals, primarily of the Baganda tribe 62.7% (220). Just over three quarters, 77.8% (273), were AGYW aged 20–24 years, and nearly a third, 37.6% (132), of the participants were unemployed. Additionally, 64.4% (226) of the participants were married or cohabiting, and 50.1% (176) had completed O'Level secondary education.

Table 2 presents important aspects of behavioural and biological practices related to sexual behaviours, healthcare utilization, and protective measures for HIV infection among the surveyed population.

Behavioural practices

Table 2 shows that the majority of the AGYW respondents, 87.3% (296), had initiated sexual activity by the age of 14 years (sexual debut), most of them 71.8% (237) were in monogamous sexual relationships, and reporting

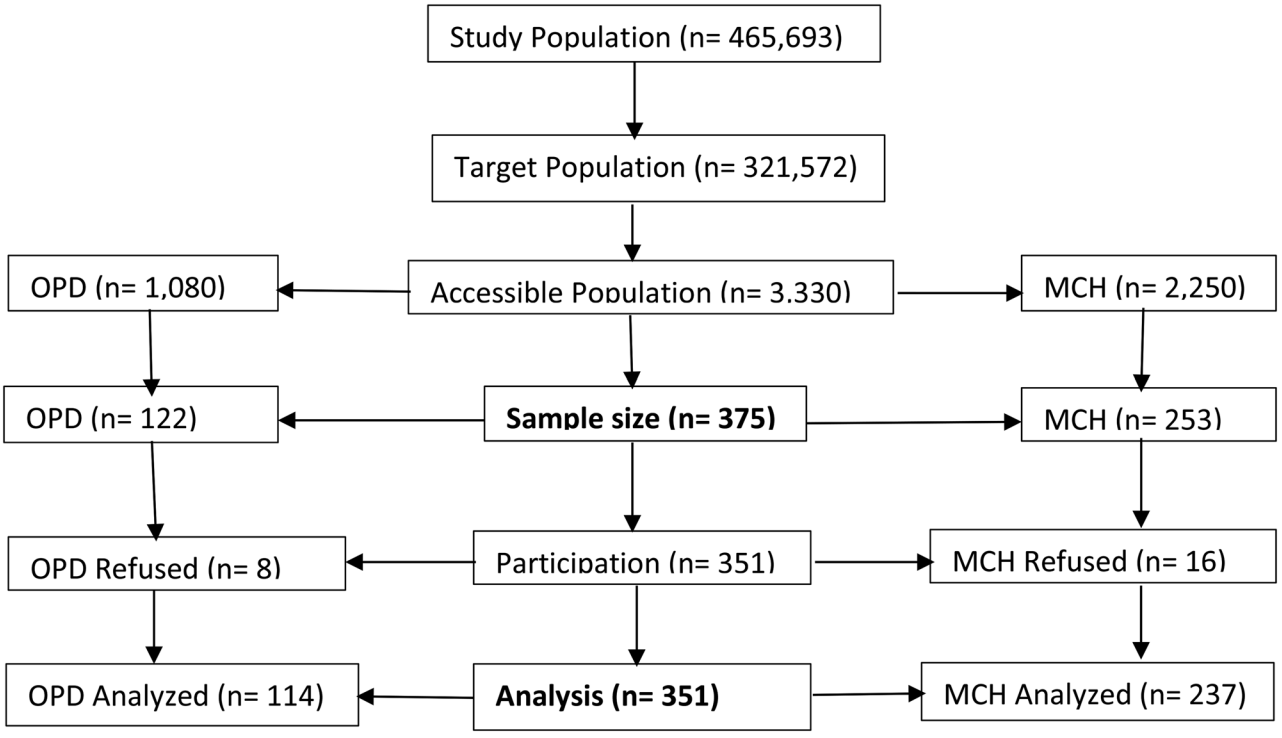

Fig. 1 Reported populations for this study Source: Primary data 2023

Table 1 Demographic characteristics of AGYW in central Uganda

Demographic Attributes		Frequency (*N* = 351)	Percentage (%)
Religion	Anglican	78	22.2
	Catholic	185	52.7
	Moslem	75	21.4
	Pentecostal	11	3.1
	Others specify	2	0.6
Tribe	Muganda	220	62.7
	Munyankole/Mukyiga	89	25.4
	Munyarwada	16	4.6
	Munyoro/Mutooro	4	1.1
	Others specify	22	6.3
Nationality	Ugandan	342	97.4
	Others	9	2.6
Occupation	Unemployed	132	37.6
	Self employed	138	39.3
	Professional job,	81	23.1
Age in years	15–17	6	1.7
	18–19	72	20.5
	20–24	273	77.8
Marital Status	Single/Never married	99	28.2
	Married/Cohabiting	226	64.4
	Separated/Divorced	25	7.1
	Widowed	1	0.3
Education level	None at all	2	0.6
	Primary	111	31.6
	O'-Level secondary	176	50.1
	A-Level secondary	11	3.1
	Tertiary/University	51	14.5

Source: Primary data, 2023

inconsistent condom use 96.1% (317). Additionally, 13.6% (45) of the respondents reported practicing transactional sex, while 7.0% (23) were engaged in cross-generational sex.

Biological practices

The findings in Table 2 reveal that the majority of the AGYW participants 91.7% (322), reported having done an HIV test and less than 1 in 10 of them, 4.2% (14) had used Pre-Exposure Prophylaxis (PrEP), which is a preventive medication for individuals at high risk of HIV infection. Additionally, about a third of the respondents, 32.1% (18), reported using PEP, which is a treatment taken after potential high-risk HIV exposure. The data shows that most AGYW participants, 84.6% (186), reported receiving treatment for sexually transmitted infections (STIs), and their male partners were circumcised, 87.0% (287).

According to Table 3, the HIV positivity rate was 5.1% among research participants.

Table 2 Behavioural and biological practices among AGYW in central Uganda

Behavioural and Biological Practices		Frequency	Percentage
Behavioural Practices			
Sexual debut (≤ 14 years)	Yes	296	87.3
	No	43	12.7
Sexual partners	Multiple	93	28.2
	Single	237	71.8
Condom Use	Consistent	13	3.9
	Inconsistent	317	96.1
Transactional sex	Yes	45	13.6
	No	285	86.4
Cross-Generational sex	Yes	23	7.0
	No	307	93.0
Biological Practices			
HIV test	Yes	322	91.7
	No	29	8.3
PREP use	Yes	14	4.2
	No	316	95.8
PEP use	Yes	18	32.1
	No	38	67.9
STI treatment	Yes	186	84.6
	No	34	15.5
Partner Circumcision	Yes	287	87.0
	No	43	13.0

Source: Primary data, 2023

Table 3 HIV infection outcomes among AGYW in the central region, Uganda

HIV Infection Outcomes	Frequency (*N* = 351)	Percentage (%)
Positive	18	5.1
Negative	333	94.9
Total	351	100.0

Source: Primary data, 2023

Mediation analysis

Hypothesized model

The standardized goodness of fit (GoF) test statistics for hypothesized model in Fig. 2 were: Root mean squared error of approximation (RMSEA) = 0.124, Standardized root mean squared residual (SRMSR) = 0.046, Comparative fit index (CFI) = 0.651, and Tucker-Lewis index (TLI) was 0.534.

Final model

The standardized goodness of fit test statistics for the final model in Fig. 3 were. RMSEA = 0.044 < 0.06, SRMSR = 0.035 < 0.08, CFI = 0.954 > 0.95, and TLI = 0.908 > 0.90. The results indicated an acceptable fit of the model in predicting HIV infection outcomes [53].

The direct sociostructural risk factors that were hypothesized were alcohol consumption, discrimination, and stigma. The indirect factors were only marital status and exposure to SGBV. The results of the fitted structural equation model are shown in Table 3, and paths are

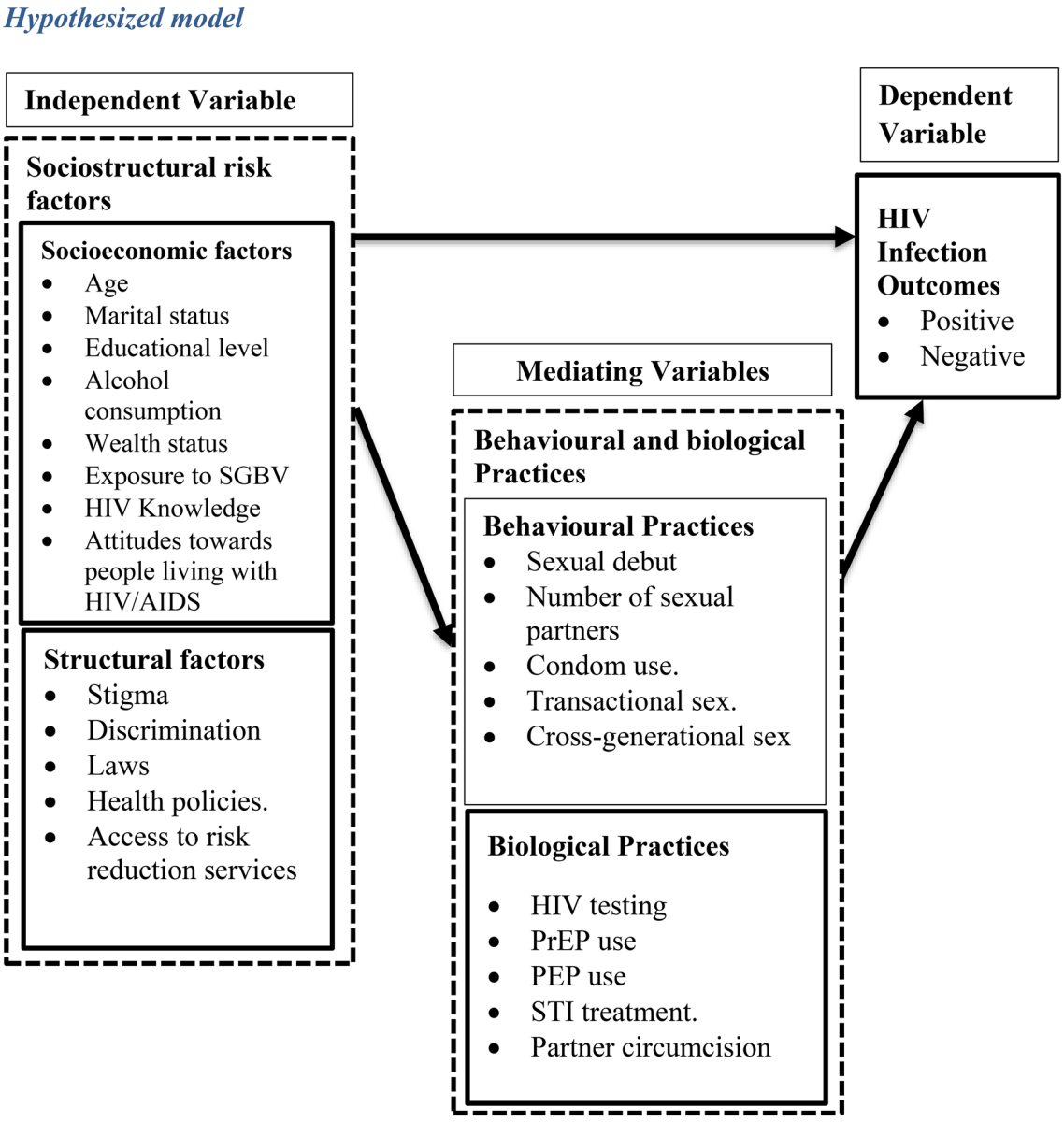

Fig. 2 Hypothesized model showing the mediating relationship between study variables Source: Primary data, 2023

illustrated in Fig. 2 as a way of testing and validating the hypothesized model.

Direct and indirect effects

Table 4; Fig. 3 results showed that PEP use (β = 0.242, $p = 0.000$), number of sexual partners (β = 0.091, $p = 0.000$), alcohol consumption (β = -0.064, $p = 0.020$), discrimination (β = 0.070, $p = 0.031$) and Stigma (β = 0.045, $p = 0.022$) among AGYW aged 15–24 years had a statistically direct significant association with HIV infection in central Uganda.

Findings further showed that alcohol consumption (β = -0.208, $p = 0.000$), marital status (β = -0.086, $p = 0.001$), SGBV exposure (β = 0.267, $p = 0.000$), and stigma (β = 0.092, $p = 0.038$) among AGYW aged 15–24 years had a statistically indirect association with HIV infection.

Compounded model

Figure 4 of the compounded model shows a direct strong path: sociostructural risk factors to HIV infection with a factor load of 0.756, and indirect weak paths: sociostructural risk factors to biological practice with a factor load of 0.362 and biological practice to HIV infection with a factor load of 0.253.

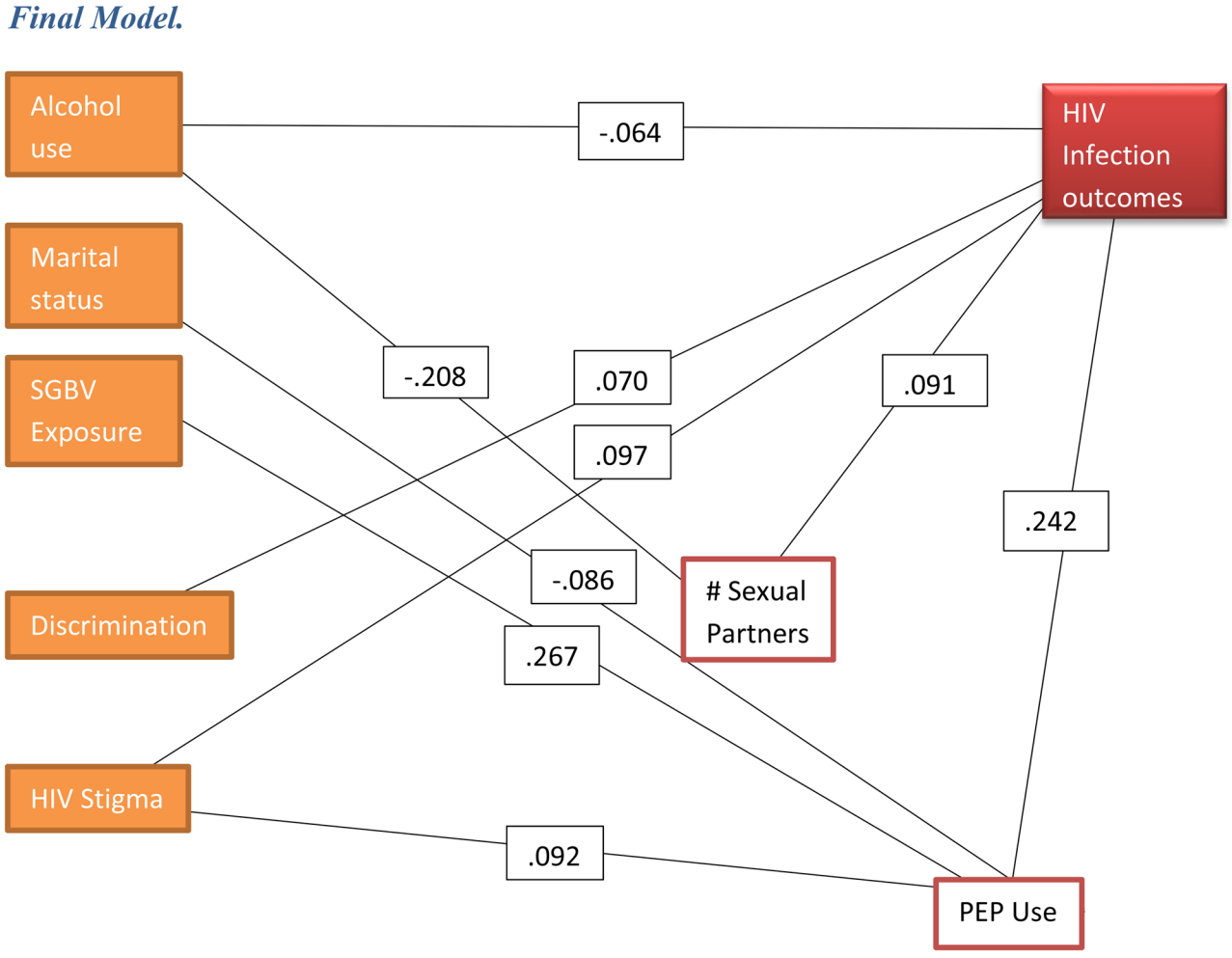

Fig. 3 Final model showing the mediating relationships between study variables Source: Primary data, 2023

Table 4 Path coefficients for the final model

Variables	Coefficientβ	Standard Error (S.E)	*p*-value	95% C. I	
				Lower	Upper
Direct Effects- HIV infection					
PEP use	0.242	0.048	**0.000****	0.148	0.336
Sexual Partners	0.091	0.026	**0.000****	0.340	0.142
Alcohol consumption	−0.064	0.028	**0.020****	−0.118	−0.010
Discrimination	0.070	0.032	**0.031****	0.006	0.133
Stigma	0.097	0.027	**0.022****	−0.007	0.097
Indirect Effects- Sex Partners					
Alcohol consumption	−0.208	0.057	**0.000****	−0.321	−0.096
Indirect Effects- PEP use					
Marital status	−0.086	0.026	**0.001****	−0.136	−0.036
SGBV exposure	0.267	0.041	**0.000****	0.187	0.347
Stigma	0.092	0.044	**0.038****	0.005	0.179

**Significant at 5% level. Source: Primary data, 2023

Discussion

This research article describes the extent to which sociostructural risk factors directly or indirectly affect behavioural and biological practices and HIV infection outcomes. The study seeks to contribute to the literature by examining the mediating effect of these practices in the relationship between sociostructural risk factors and HIV infection outcomes among AGYW in central Uganda.

Our findings indicated an HIV positivity rate of 5.1%. PEP use, number of sexual partners, alcohol consumption, discrimination, and stigma among AGYW aged 15–24 years had a statistically significant direct association with HIV infection in central Uganda. Additionally, alcohol consumption, marital status, SGBV exposure, and stigma, among AGYW aged 15–24 years, had a statistically significant indirect association with HIV infection.

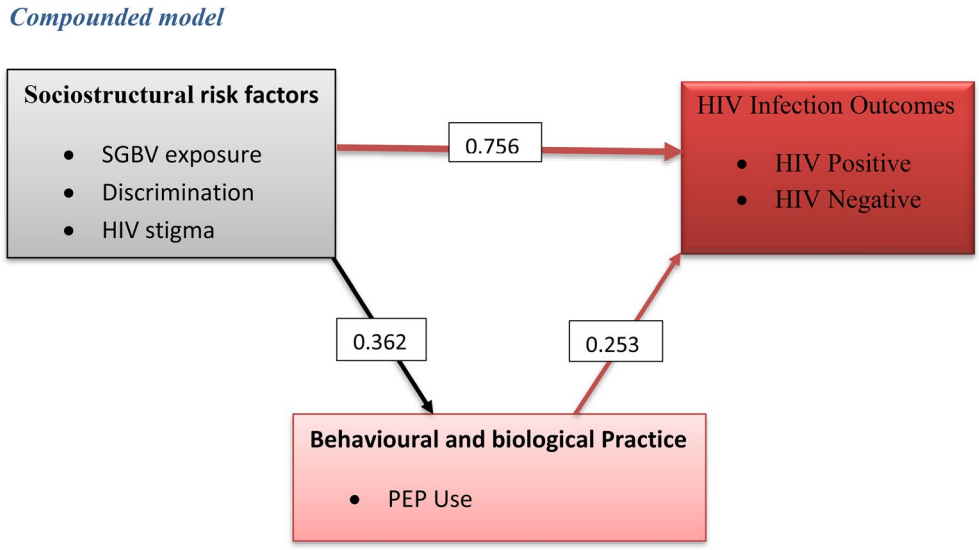

Fig. 4 Compounded Model showing the mediating relationships between study variables Source: Primary data, 2023

HIV prevalence among among AGYW aged 15–24 in central, Uganda

Our findings indicated a strikingly higher HIV infection prevalence of 5.1% compared to 2.9% reported for the period 2020–2021 among AGYW aged 15–24 in central, Uganda [8]. The higher HIV positivity rate among AGYW respondents indicates prevailing risky behavioral and biological practices and unsatisfactorily healthcare policies demonstrating a clear urgent need to understand the relationships between the risky practices and sociostructural factors that is necessary to develop targeted risk reduction interventions for addressing new HIV infections in this population subgroup and contribute to the end of HIV/AIDS pandemic by 2030 [2].

Behavioural and biological practices and HIV infection outcomes among AGYW in central region, Uganda

PEP use and the number of sexual partners among AGYW aged 15–24 years had a statistically significant direct association with HIV infection in central Uganda. The unexpected finding of a positive statistical relationship between PEP use and HIV infection suggests that PEP use among AGYW increases the risk of HIV acquisition. This contradicts previous studies [54, 55], which indicate that fast use of PEP, ideally within two hours and not later than 72 hours after exposure, can prevent HIV infection [56]. It is possible that AGYW who have been exposed to HIV are more likely to seek out PEP as a preventive measure. Alternatively, it is also possible that AGYW who have used PEP may engage in riskier sexual behaviour, increasing their likelihood of exposure to HIV.

Other studies have documented several factors that influence the relationship between PEP use and HIV infection outcomes, including the presence of genital ulcers [57], viral load of the source person, and the form of HIV exposure [54]. These findings highlight the importance of promoting PEP use among AGYW alongside other HIV prevention services, such as increasing HIV awareness, STI treatment, and prevention of SGBV. Further research is needed to explore the underlying factors and mechanisms that may further explain these associations.

The finding that the number of sexual partners is significantly associated with HIV infection status among AGYW aged 15–24 years is consistent with the results of past studies in South Africa [13, 58], which found that having multiple sexual partners increases the risk of HIV infection among young women. This suggests that having multiple sexual partners is a key behavioural risk factor for HIV infection among AGYW in the study population. This highlights the importance of promoting safe sexual behaviours, including abstinence and reducing the number of sexual partners.

Sociostructural risk factors and HIV infection outcomes among AGYW in central region, Uganda

Alcohol consumption, discrimination, and stigma among AGYW aged 15–24 years had a statistically significant direct association with HIV infection in central Uganda. The finding that alcohol consumption was significantly associated with HIV infection aligns with previous research in Botswana [59], in South Africa [12], and in the United States [60], which found that alcohol use was associated with increased sexual risk-taking behaviours and HIV infection outcomes. The finding implies that alcohol consumption promotes risky sexual behaviours and its associated with increased HIV vulnerability. Altogether, the findings support the current study results

that indicate that alcohol use as a sociostructural factor contributes to the risk of HIV infection among AGYW in central Uganda. The result highlights the importance of targeting AGYW aged 15–24 years with interventions comprising multiple preventive approaches to increase their awareness of the dangers of alcohol use and utilization of several HIV risk reduction services.

Our finding that discrimination is associated with HIV infection among AGYW in Central Uganda aligns with previous research in South Africa [61], which found that discrimination was associated with HIV infection outcomes and the use of HIV prevention services. However, it contradicts a study in Tanzania [62], which found that, although discrimination was a common experience among AGYW, it was not directly associated with HIV infection. This suggests that addressing discrimination against PLHIV is crucial for supporting HIV risk reduction initiatives. These findings should be considered when designing interventions for HIV prevention and risk reduction among AGYW, focusing on addressing discrimination and promoting safe biological practices.

We also found that stigma is significantly associated with HIV infection status among AGYW. This finding is consistent with previous research in Bangladesh [63] and in sub-Saharan Africa [64], where stigma was associated with higher HIV positivity among teenagers and young adults. Stigma against PLHIV among AGYW may prevent them from seeking several HIV risk reduction services leading to their increased risk of acquiring HIV infections. It is important to consider the finding that stigma is a significant barrier for uptake of prevention services when designing interventions to reduce HIV infection among AGYW. Further research is needed to explore the underlying factors and mechanisms that may explain these associations.

Sociostructural risk factors and behavioural, biological practices in relation to HIV infection among AGYW in central region, Uganda

Alcohol consumption, marital status, SGBV exposure, and stigma, among AGYW aged 15–24 years, had a statistically significant indirect association with HIV infection. The finding that alcohol use is significantly associated with number of sexual partners as a behavioural practice among AGYW in the Central region of Uganda is consistent with previous studies in South Africa [65], in Canada [66] and the United States [60] which found that alcohol use was a significant predictor of having multiple sexual partners among young women, putting them at higher risk for new HIV Infection. These findings altogether suggest that alcohol use as a sociostructural factor contributes to the risk of HIV infection among AGYW in the Central region of Uganda. Alcohol use can trigger sexual promiscuity among AGYW which may increase their risk of HIV acquisition. This highlights the importance of addressing alcohol consumption as a risk factor for HIV infection among AGYW.

Our finding that marital status is significantly associated with PEP use among AGYW in the Central region of Uganda aligns with studies in China [67] and South Africa [68] that found that being married or in a stable partnership was associated with a lower likelihood of using HIV prevention methods, including PEP. This may be due to a perceived lower risk within marital relationships, leading to a decreased emphasis on preventive measures.

Conversely, in Ethiopia [69], unmarried individuals were more likely to access HIV prevention services, including PEP, compared to those who were married or cohabiting. These findings suggest that marital status influences access to and utilization of HIV prevention services such as PEP. The significant association between marital status and PEP use in the current study highlights the importance of addressing the unique challenges faced by unmarried AGYW in accessing and utilising PEP services. It also emphasises the need for targeted interventions that promote PEP use within marital relationships.

Our results show that exposure to SGBV is significantly associated with PEP use for HIV risk reduction among AGYW in the Central region of Uganda. This finding aligns with previous studies in India [70] and in South Africa [65], where women exposed to SGBV were found to be more likely to engage in risky practices, including delayed PEP initiation. In Uganda, exposure to SGBV is an indication for PEP. The perception of a lower risk of HIV among the AGYW exposed to SGBV and initiated on PEP may lead to decreased emphasis on completing PEP as a preventive measure for HIV. Therefore, this perception should be explored in future research. It is important to note that while the finding highlights the association between SGBV and PEP use as a risk factor for HIV infection, they do not establish a causality. Other factors, such as wealth status, educational level, HIV knowledge, attitudes, and access to PEP services, may also contribute to the observed association.

The finding that there is an association between stigma and PEP use among AGYW in central Uganda indicates that AGYW who experience stigma may be more likely to take up prevention services, such as using PEP. However, several studies have highlighted the detrimental impact of stigma on HIV prevention among AGYW. For example, a study in sub-Saharan Africa [64] found that stigma was associated with a higher likelihood of engaging in HIV risky behaviours. It is important to consider these findings when designing interventions to address HIV prevention and risk reduction among AGYW, focusing on addressing stigma and promoting safe HIV prevention practices, including increased uptake of PEP. Further

research is needed to explore the underlying factors and mechanisms that may explain these associations.

Partial least squares structural equation modelling and path analysis

The resultant standardized goodness of fit (GoF) test statistics results based on the cut-off criteria for fit indices showed unacceptable fit of the hypothesized model in predicting HIV infection outcomes [53] explained by the results of: RMSEA = 0.124 > 0.06, SRMSR = 0.046 < 0.08, CFI = 0.651 < 0.95, and TLI was 0.534 < 0.9. The GoF test results for the final model indicated an acceptable fit in predicting HIV infection outcomes [53] given the specific results for RMSEA = 0.044 < 0.06, SRMSR = 0.035 < 0.08, CFI = 0.954 > 0.95, and TLI = 0.908 > 0.90.

The path analysis results indicate that the most significant effect was found in the pathway: SGBV→ PEP use →HIV infection, contributing 6.5% of the total effects using a multiplicative model that was applied to evaluate the causal model as a way of deciding on most appropriate path to be adopted for control of HIV infection. This was followed by path 2: Stigma→ PEP use →HIV infection, path 3: Marital status → PEP use →HIV infection and path 1: Alcohol use → Sex Partners →HIV infection sequentially that are contributing 2.2%, 2.1% and 1.9% of the total effects respectively. This results suggests that addressing path 1: SGBV→ PEP use →HIV infection where the highest effect was felt,,is crucial for controlling HIV infection among AGYW.

Overall, all the paths combined contribute 12.7% of the total effects on HIV infection, which is significantly below 50%. Therefore, future research should evaluate other potential risk pathways mediating the relationship between sociostructural risk factors and HIV infection outcomes among the AGYW, such as the effect of social networks (dyads), psychosocial factors, and self-efficacy in future research.

A compounded model had a perfect fit in predicting HIV infection outcomes that was reached when the RMSEA was 0.000 < 0.06, the SRMSR was 0.017 < 0.08, the CFI was 1.000 > 0.95, and the TLI was 1.010 > 0.90 [53, 71]. This implied that the sociostructural risk factors (SGBV exposure, discrimination, HIV stigma) and the biological practice (PEP Use), both direct and indirect variables, are a perfect fit in predicting HIV infection outcomes among the AGYW.

Additionally, the paths result of the fitted structural equation model showed a direct strong path from sociostructural risk factors to HIV infection with a factor load of 75.6%. Indirect weak paths were found from sociostructural risk factors to biological practice with a factor load of 36.2% and from biological practice to HIV infection with a factor load of 25.3%. This suggests that addressing both sociostructural risk factors and biological practices can significantly reduce new HIV infections.

Study limitations

A cross-sectional research was conducted by the researcher within a stipulated budget as opposed to a longitudinal study that would otherwise explore and analyze AGYW behaviours and practices over a long period of time to attain a broader understanding of the influence of particular behavioral and biological practices on sociostructural factors and HIV infection outcomes among AGYW in Central Uganda. The study was limited to a representative sample over the period of 12 months due to the high expenses involved in terms of time and funds if a longitudinal study was conducted.

Another limitation of this cross-sectional study was the antecedent-consequent bias, since both the HIV risk factors and HIV Infection outcomes were measured at the same time. The researcher was not able to determine if risk preceded disease and vice versa since both were assessed concurrently, unlike in clinical trials or cohort studies where the subjects are selected for study because they are disease-free. However, the descriptive study was still an important method to evaluate the mediating effect of behavioural and biological practices in the relationship between sociostructural risk factors and HIV infection outcomes because descriptive cross-sectional studies are widely used to measure the occurrence of disease risks in population segments characterized by sex, age, race or socioeconomic status [72].

The researcher employed approaches such as rigorous sampling, comprehensive data collection and statistical controls to address limitations. A random sampling technique and a large sample of 375 participants were considered to accurately represent the broader population of AGYW, enhancing the generalizability of research findings. The study employed a reliable and validated semi-structured questionnaire to ensure quality data is collected and utilized advanced statistical technique of multiple regression to control for co-founding and ensure accurate results of the mediating effect of behavioural and biological practices in the relationship between sociostructural risk factors and HIV infection outcomes.

The strengths of the study were its ability to collect quality data from a large sample at one time, enabling the evaluation of multiple variables and the identification of potential associations. Also, the study effectively described the AGYW population characteristics, including demographics, behaviors and HIV status outcomes with no deliberate exposure or treatment that occur with experimental or intervention studies.

Conclusions

The findings of the study suggest specifically, PEP use (β = 0.242, $p = 0.000$) and number of sexual partners (β = 0.091, $p = 0.000$) as behavioural and biological practices had a mediating effect on the association between sociostructural risk factors of alcohol consumption (β = -0.064, $p = 0.020$), marital status (β = -0.086, $p = 0.001$), SGBV exposure (β = 0.267, $p = 0.000$), discrimination (β = 0.070, $p = 0.031$), and stigma (β = 0.092, $p = 0.038$) and HIV infection outcomes among AGYW in Central region. These findings highlight the effect of reducing the number of sexual partners, alcohol consumption, discrimination, and stigma, as well as sensitization on the appropriate use of PEP in reducing new HIV infection among AGYW in central Uganda.

The study recommends addressing alcohol consumption, discrimination, stigma and other unique challenges faced by married AGYW and survivors of SGBV such as multiple sexual partnerships and PEP use through targeted AGYW comprehensive interventions which can effectively improve access to necessary HIV prevention services and significantly reduce new HIV infection among the AGYW. Further research is needed to better understand the complex interplay of these factors and their impact on HIV risk among AGYW.

Operational definition study variables

Cross-generational sex This is defined as sex with a much older partner (an age gap of 10 years or more).

Discrimination Is a biased act of unlawfully treating a person with contempt due to personal differences in culture, social and economic status and physical body features or personal conditions or status [74].

Health policy A public course, interpretation or principle intended, proposed or adopted by government/ company/ organization on a given health situation/issue and to be implemented or chosen not to be done by the relevant public or private actors. Health policies can lead to establishment of new laws.

HIV infection Refers to a viral infection that is transmitted via exposure to infected body fluids such as semen, blood, breast milk and vaginal fluids. HIV destroys CD4 cells (white blood cells), rendering the host unable to fight off secondary infections [1].

Law Is a set of principles, procedures, and standards that must be observed in implementation of justice in the society. Courts administer the laws.

Partner circumcision A spouse or a person with whom a person is having a sexual relationship being circumcised.

Post-exposure prophylaxis (PEP) Refers to the use of antiretroviral drugs to stop HIV seroconversion after a high-risk event.

Pre-exposure prophylaxis (PrEP) Refers to the medicine people at risk for HIV take to prevent getting HIV from sex or injection drug use.

Risk reduction services Refers to services the decrease the probability that a person may acquire HIV infection.

Sexual gender-based violence (SGBV) Refers to any form of sexual act, comments or advances using coercion, threats of harm or physical force, by any person, regardless of their relationship to the survivor, in any setting. It includes forced sex, sexual coercion and rape of an adult, an adolescent, a child, men and women, and often due to power differences between male and female.

Sexually transmitted infection (STI) Refers to infection such as syphilis, chancroid, chlamydia and gonorrhoea that spread through sexual contact.

Stigma Refers to an attitude of mind founded in the tradition, culture or belief of a community in which one person disregards the status of another person due to perceived 'uncommon' body features or personal conditions or status [74].

Transactional sex is defined as sex in exchange for money or other items in which the person providing sex does not regard her/himself as a sex worker (practicing sex as an occupation).

Abbreviations

AGYW	Adolescent Girls and Young Women
AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral Therapy
CFI	Comparative Fit Index
GoF	Goodness of Fit
HIV	Human Immuno-Deficiency Virus
MOH	Ministry of Health
PEP	Post-Exposure Prophylaxis
PrEP	Pre-Exposure Prophylaxis
RMSEA	Root Mean Squared Error of Approximation
SGBV	Sexual and Gender-Based Violence
SRMSR	Standardized Root Mean Squared Residual
TLI	Tucker-Lewis index
UAC	Uganda AIDS Commission
UBOS	Uganda Bureau of Statistics
UNAIDS	United Nations Programme on HIV/AIDS
UPHIA	Uganda Population-Based HIV Impact Assessment
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1

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Author contributions
IM conceived the research idea and conceptualised the study. RCN, MM and IM participated in the design of the study including writing the protocol, refining the data tools and coordinating the data collection. CD and IM participated in the statistical data analysis. All authors contributed to interpretation of the results and the writing of the manuscript, and all approved the final manuscript.

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Data availability
The datasets used during the current study are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate
The study protocol was cleared by the Uganda National Council for Science and Technology (NCST) (HS2554ES) and the Clarke International University Research Ethics Committee (CLARKE-2022-453). All participants provided written informed consent inform of a signature or thumbprint after explaining the purpose and nature of the research to the participants prior to the survey. Participation in the study was voluntary and the research participants were informed of their right to withdraw from study at any stage of the study or refuse to participate without any penalty, as per acceptable ethical standards in the Declaration of Helsinki [73]. The researcher ensured the anonymity of the research participants and confidentiality of the responses by assigning all participant information and blood samples with unique identifiers so as participants' names do not appear anywhere in the research findings [45].

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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