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# Sexual Behavior Patterns Among Older Adults with Non-Marital Heterosexual Encounters in Six Provinces of China: A Multi-site Latent Class Analysis

**JUAN YANG**
National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention

**Jiahong Liu**
Jiangxi Provincial Center for Disease Control and Prevention

**Liang Lu**
Nanchang Municipal Center for Disease Control and Prevention

**Jie Chen**
Hunan Provincial Center for Disease Control and Prevention

**Yanbo Wan**
Yongzhou Municipal Center for Disease Control and Prevention

**Shujia Liang**
Guangxi Zhuang Autonomous Region Center for Disease Control and Prevention

**Li Wei**
Liuzhou Municipal Center for Disease Control and Prevention

**Chao Zhou**
Chongqing Municipal Center for Disease Control and Prevention

**Hehong Jiang**
Chongqing Municipal Center for Disease Control and Prevention

**Liao Feng**
Sichuan Provincial Center for Disease Control and Prevention

**Chengyi Xiang**
Sichuan Provincial Center for Disease Control and Prevention

**Huijuan Chen**
Guizhou Provincial Center for Disease Control and Prevention

**Siqi Dai**
Guizhou Provincial Center for Disease Control and Prevention

**Peng Xu**
National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention

**Mengchi Liu**
National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention
**Yufen Liu**
gracefulyang@chinaaids.cn

National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention

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## Abstract

# Background

China is experiencing a growing human immunodeficiency virus (HIV) epidemic among adults aged 50 years and older, yet the heterogeneity of their sexual risk behaviors remains understudied. This study used latent class analysis to identify sexual behavior patterns and examined their associations with sociodemographic and HIV-related factors.

# Methods

A multi-site community-based cross-sectional survey was conducted in six provinces of China in 2024. A total of 1,698 adults aged 50 years and older who reported non-marital heterosexual encounters met the eligibility criteria and had complete data. Latent class analysis was performed using four indicators: partner type, number of partners, condom use, and sexual frequency. The optimal number of classes was determined by the Bayesian information criterion, entropy, and interpretability. Multinomial logistic regression was used to examine how sociodemographic and HIV-related factors were associated with latent class membership, with the low-risk class as the reference, both overall and by gender.

# Results

A three-class solution was selected. Class 1 (high-risk, 9.60%) was characterized by mixed or multiple partners and high sexual frequency. Class 2 (moderate-risk, 44.35%) was characterized by commercial or multiple partners and moderate sexual frequency. Class 3 (relatively low-risk, 46.05%) was characterized by a single non-commercial partner and low sexual frequency. Older age, female gender, extremely low income, and living with others were associated with the relatively low-risk class. Male gender, unmarried status, younger age, lower education, living alone, sexual activity driven primarily by physical needs, and employment in commercial service occupations were independent risk factors for the moderate- and high-risk classes. Gender-stratified analysis showed that high-risk sexual behavior in men was significantly associated with age, education, occupation, income, and marital status, whereas sexual risk in women was largely independent of socioeconomic characteristics. Condom use was low across all classes.

# Conclusions

These findings reveal three distinct sexual behavior patterns with gender-specific correlates, highlighting the need for tailored, gender-differentiated prevention strategies to curb the rising HIV epidemic among older adults.

# Introduction

China's HIV epidemic is undergoing notable shifts in age distribution. The share of newly reported HIV/AIDS cases among adults aged 50 years and above has increased continuously [1], rendering this population a key focus for national HIV prevention and control. Epidemiological analyses indicate that HIV transmission in this group mainly occurs via heterosexual intercourse [2]. Under the influence of traditional Chinese culture, older adults' sexual needs are frequently neglected, and they have limited access to formal sex education, despite their genuine physical demands [3]. Divorce, bereavement, solitary living, and loneliness further contribute to the prevalence of extramarital sexual activity among this population [4]. Older adults in China generally exhibit low educational attainment and inadequate sexual health awareness. Consequently, unsafe extramarital sexual behaviors, including multiple sexual partnerships and unprotected intercourse, are prevalent in this population, which substantially elevates their susceptibility to HIV infection [5, 6]. Accordingly, older adults engaging in extramarital heterosexual behavior constitute a critical target population and a core research priority for national HIV prevention and control in China.

Current HIV interventions for older adults in China are limited in diversity, targeted effectiveness and overall outcomes. This is largely attributable to insufficient in-depth research on this population, particularly regarding their sexual behavioral characteristics. Most existing studies on sexuality focus on younger populations, while research regarding sexual behaviors and their health impacts among older adults remains limited [7]. Existing HIV-related studies on older adults mainly focus on prevalence and influencing factors, frequently treating this population as a homogeneous group and ignoring heterogeneous risk characteristics among subgroups [8, 9], thereby overlooking subgroups with distinct risk profiles. Relevant data show that for male HIV-positive individuals, commercial heterosexual transmission constituted the primary infection pathway. In contrast, extramarital non-commercial heterosexual transmission was the most common route among females, responsible for 60.59% of female infections [2]. These findings indicate that different patterns of sexual behavior correspond to varying HIV infection risks. Therefore, differentiated intervention strategies should be developed targeting distinct behavioral types.

Latent class analysis (LCA) serves as an effective approach to identify health-related issues [10]. As a statistical technique, it detects group heterogeneity by classifying individuals into latent categories according to their shared behavioral patterns [11]. While this analytical approach is commonly employed in HIV research among adolescents, young adults and sexual minorities, its application in older adult populations remains limited [12–14]. Identifying distinct behavioral patterns can inform targeted HIV prevention interventions.

Therefore, this study aims to apply LCA to identify distinct behavioral patterns among older adults, and explore the associations between these patterns and factors including sociodemographic characteristics, HIV testing behaviors, HIV knowledge level and HIV risk perception. Based on the

findings, we will scientifically classify the elderly population, so as to provide evidence for the development of differentiated intervention strategies.

# Methods

### Study Design and Participants

This survey was conducted from June to December 2024 in ten county-level regions of six provinces in China. We adopted a cross-sectional design. At the site-selection level, we used purposive sampling; at the individual level, we used convenience sampling, a type of non-probability sampling. Participants were older adults who reported non-marital heterosexual behaviors. At the provincial level, we deliberately selected six provinces in China with a relatively heavy HIV/AIDS burden among older adults. Within each selected province, we further selected counties or districts with a relatively high number of reported HIV/AIDS cases. From each selected county or district, we then selected townships or sub-districts with a relatively high number of reported cases and a dense older population as the specific survey sites. At the individual level, convenience sampling was used to recruit eligible participants because this population is hidden and hard to reach under limited resources and time. This strategy may limit the representativeness of the findings. Inclusion criteria: (1) age ≥ 50 years, (2) self-reported extramarital heterosexual encounters within the past 12 months, (3) permanent residency in the study area for ≥ 3 months, and (4) ability to provide informed consent. A total of 1698 met the criteria and had complete data on all LCA indicators.

# Collected Data

The questionnaire adopted in this study consisted of three parts. First, sociodemographic characteristics, including age, gender, educational level, occupation, marital status, residential status, monthly income, and household registration. Second, HIV-related knowledge was evaluated via the nationally standardized 8-item questionnaire issued by the Chinese Center for Disease Control and Prevention[1]. Third, behavioral and HIV-related indicators, covering sexual partner type, sexual motivation, HIV risk perception, number of sexual partners, condom use status, frequency of sexual behavior, and HIV testing uptake.

# Measures

**LCA indicators**: We adopted four categorical variables as indicators in the LCA. Partner type was divided into three categories: exclusive commercial partners (coded 0), exclusive non-commercial partners (coded 1), and a combination of the two (coded 2). The total number of sexual partners in past one year was grouped into four levels: one partner (0), two up to five partners (1), six up to ten partners (2), and more than ten partners (3). Responses regarding condom use were coded as never use (0), occasional use (1), frequently use (2) and always use (3). Sexual activity frequency in past one year was categorized as two times or fewer (0), three to six times (1), seven to twelve times (2), thirteen times or more (3).

**Sociodemographic covariates**: Age group (50–59, 60–69, 70–79, ≥ 80), gender (male/female), educational attainment (Primary school or less, junior high school, senior high school or above), occupation (Farmer, Worker, Retiree, Commercial service staff, Unemployed and Other), marital status (Married, Unmarried, Widowed or divorced), Living alone (yes or no), monthly income (≤ 1000, 1001–3000, 3001–5000, > 5000 RMB), household registration (local, non-local).

**HIV-related knowledge**: The questionnaire consisted of eight standardized questions: whether people living with HIV can be identified by appearance, whether HIV can be transmitted through mosquito bites or daily dining with HIV-infected individuals, whether HIV infection can occur via transfusion of HIV-contaminated blood or sharing syringes with HIV-positive persons, whether vertical HIV transmission exists among infants born to HIV-positive women, whether correct condom use can reduce HIV transmission, and whether maintaining a single sexual partner can lower the risk of HIV infection. One point was assigned for each correct response. The aggregate score of the eight items indicated respondents' HIV-related knowledge level. Participants were classified into two categories: adequate knowledge (score > 5) and inadequate knowledge (score ≤ 5).

**HIV-related psychological and behavioral indicators**

Three HIV-related indicators were assessed. HIV risk perception included two categories: No risk consideration and concerned but optimistic bias. Motivation was divided into curiosity, conformity and others, emotional needs, physical needs. Recent HIV testing uptake was recorded as a binary variable (yes/no), referring to whether participants had been tested for HIV in recent years.

# Statistical Analysis

LCA was performed using the poLCA package in R (version 4.3.2). Models with 2 to 5 classes were estimated with 50 random starts to avoid local maxima. Model selection was based on the Bayesian information criterion (BIC; lower is better), Akaike information criterion (AIC), entropy (≥ 0.8 indicates good classification), and substantive interpretability. After selecting the optimal model, each participant was assigned to their most likely class based on posterior probabilities.

Multinomial logistic regression (using the nnet package) was used to examine how sociodemographic and HIV-related factors were associated with latent class membership, with the low-risk class as the reference.

# Results

**Participant Characteristics**

The final analytical sample consisted of 1,698 individuals. The mean age was 61 ± 8.2 years, and 68.5% were male.

# Latent Class Analysis

Model fit indices for 2- to 5-class solutions are presented in Table 1. The 3-class solution was selected as optimal based on the lowest BIC (13,735.4), high entropy (0.92), and meaningful class interpretation. The 4-class model showed a negligible decrease in BIC but lower entropy, and the 5-class model failed to converge (entropy = NaN).

Table 1
Fit statistics for latent class models (2–5 classes, N = 1,698)

| Classes | Log_likelihood | AIC | BIC | Entropy |
|---|---|---|---|---|
| 2 | -6846.816435 | 13739.63287 | 13864.68862 | 0.845036677 |
| 3 | -6737.559397 | 13545.11879 | 13735.42102 | 0.920183719 |
| 4 | -6651.008269 | 13396.01654 | 13651.56524 | 0.771585702 |
| 5 | -6618.652063 | 13355.30413 | 13676.0993 | NaN |

Table 2 displays the item-response probabilities for the three latent classes across the four behavioral indicators (partner type, number of partners, condom use, and sexual frequency).

Class 1 (High-risk pattern, 9.60%) had a high probability of mixed partner types (commercial and non-commercial), a high probability of multiple partners (≥ 2), frequent unprotected sex, and a high probability of high sexual frequency. Class 2 (Moderate-risk pattern, 44.35%) was characterized by a high probability of commercial partner types, multiple partners, inconsistent condom use, and moderate sexual frequency. Class 3 (Relatively low-risk pattern, 46.05%) had a high probability of a single non-commercial partner, a high probability of low sexual frequency, but also low condom use. Notably, condom use was low across all three classes: the probabilities of “never” or “sometimes” using condoms exceeded 0.70 in each class.

Table 2
Item-response probabilities across four behavioral indicators for the three latent classes

| partner_type | Class 1 | Class 2 | Class 3 |
|---|---|---|---|
| Commercial | 0.436416729 | 0.47591763 | 0.23674417 |
| Non-commercial | 0.045351396 | 0.278893685 | 0.691634798 |
| Mixed type | 0.518231874 | 0.245188685 | 0.071621032 |
| number_of_partners | | | |
| 1 person | 1.44258E-23 | 7.73224E-20 | 0.995813977 |
| 2–5 persons | 0.377755931 | 0.979252034 | 2.85586E-20 |
| 5–10 persons | 0.336361197 | 0.020747966 | 4.33665E-82 |
| more than 10 persons | 0.285882872 | 8.7397E-126 | 0.004186023 |
| condom_use | | | |
| Never | 0.333023589 | 0.399270687 | 0.565187958 |
| Occasionally | 0.496679584 | 0.404649844 | 0.214915128 |
| Frequently | 0.107800942 | 0.137968194 | 0.098445893 |
| every time | 0.062495886 | 0.058111275 | 0.121451021 |
| sexual_frequency | | | |
| 2 times or less | 3.25982E-12 | 0.432078807 | 0.729922697 |
| 3–6 times | 0.307603008 | 0.498879912 | 0.202105566 |
| 7–12 times | 0.379971843 | 0.064411732 | 0.030712241 |
| 13 times or more | 0.312425149 | 0.004629549 | 0.037259496 |

**Comparison of latent classes**

Table 3 presents the sociodemographic and HIV-related characteristics of the 1,698 participants, stratified by gender and latent class. Among men (n = 1231, 72.50%), the distribution across classes was: Class 1 11.0%, Class 2 50.4%, Class 3 38.7%. Among women (n = 467, 27.50%), the class distribution was: Class 1 6.0%, Class 2 28.5%, Class 3 65.5%.

In the male subsample, significant interclass differences were found in age group, marital status, monthly income, occupation, living arrangement, HIV risk perception, and partner-seeking motives ($p < 0.001$), as well as HIV-related knowledge ($p = 0.02$).

Among women(n = 467, 27.43%), significant interclass differences were marital status($p < 0.05$), detected for occupation ($p = 0.02$), partner-seeking motives ($p < 0.001$), living arrangement and HIV risk perception ($p < 0.01$).

Table 3
Sociodemographic and HIV-related characteristics stratified by gender and latent class

| Variable | Class_1 | Class_2 | Class_3 | Class_1 | Class_2 | Class_3 |
|---|---|---|---|---|---|---|
| age_group(year) | Male(p < 0.001) | | | Female(P = 0.13) | | |
| 50–59 | 69 (51.1%) | 295 (47.6%) | 193 (40.5%) | 25 (89.3%) | 83 (62.4%) | 188 (61.4%) |
| 60–69 | 46 (34.1%) | 235 (37.9%) | 156 (32.8%) | 3 (10.7%) | 42 (31.6%) | 94 (30.7%) |
| 70–79 | 19 (14.1%) | 73 (11.8%) | 95 (20%) | 0 (0%) | 7 (5.3%) | 23 (7.5%) |
| ≥ 80 | 1 (0.7%) | 17 (2.7%) | 32 (6.7%) | 0 (0%) | 1 (0.8%) | 1 (0.3%) |
| household registration | Male(p = 0.12) | | | Female(P > 0.95) | | |
| local | 128 (94.8%) | 600 (96.8%) | 467 (98.1%) | 26 (92.9%) | 126 (94.7%) | 290 (94.8%) |
| non local | 7 (5.2%) | 20 (3.2%) | 9 (1.9%) | 2 (7.1%) | 7 (5.3%) | 16 (5.2%) |
| educational level | Male(p = 0.28) | | | Female(P = 0.23) | | |
| senior high school or above | 12 (8.9%) | 60 (9.7%) | 61 (12.8%) | 1 (3.6%) | 22 (16.5%) | 44 (14.4%) |
| junior high school | 43 (31.9%) | 222 (35.8%) | 172 (36.1%) | 11 (39.3%) | 46 (34.6%) | 88 (28.8%) |
| Primary school or less | 80 (59.3%) | 338 (54.5%) | 243 (51.1%) | 16 (57.1%) | 64 (48.1%) | 173 (56.5%) |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.8%) | 1 (0.3%) |
| Marital status | Male((p < 0.001) | | | Female(P = 0.04) | | |
| Married | 45 (33.3%) | 316 (51%) | 271 (56.9%) | 13 (46.4%) | 99 (74.4%) | 195 (63.7%) |
| Unmarried | 49 (36.3%) | 144 (23.2%) | 95 (20%) | 2 (7.1%) | 4 (3%) | 18 (5.9%) |
| Widowed or divorced | 41 (30.4%) | 160 (25.8%) | 110 (23.1%) | 13 (46.4%) | 30 (22.6%) | 93 (30.4%) |
| Monthly Income(RMB) | Male((p < 0.001) | | | Female(P = 0.62) | | |
| ≤ 1000 | 56 (41.5%) | 260 (41.9%) | 243 (51.1%) | 8 (28.6%) | 45 (33.8%) | 123 (40.2%) |
| 1001–3000 | 53 (39.3%) | 253 (40.8%) | 168 (35.3%) | 16 (57.1%) | 65 (48.9%) | 137 (44.8%) |

| Variable | Class_1 | Class_2 | Class_3 | Class_1 | Class_2 | Class_3 |
|---|---|---|---|---|---|---|
| 3001–5000 | 13 (9.6%) | 89 (14.4%) | 50 (10.5%) | 3 (10.7%) | 17 (12.8%) | 28 (9.2%) |
| > 5000 | 13 (9.6%) | 18 (2.9%) | 15 (3.2%) | 1 (3.6%) | 6 (4.5%) | 18 (5.9%) |
| Occupation | Male((p < 0.001) | | | Female(P = 0.02) | | |
| Farmer | 94 (69.6%) | 432 (69.7%) | 351 (73.7%) | 13 (46.4%) | 75 (56.4%) | 163 (53.3%) |
| Worker | 17 (12.6%) | 67 (10.8%) | 40 (8.4%) | 1 (3.6%) | 10 (7.5%) | 34 (11.1%) |
| Retiree | 4 (3%) | 25 (4%) | 31 (6.5%) | 1 (3.6%) | 15 (11.3%) | 35 (11.4%) |
| Commercial service staff | 15 (11.1%) | 24 (3.9%) | 11 (2.3%) | 6 (21.4%) | 11 (8.3%) | 11 (3.6%) |
| Unemployed | 5 (3.7%) | 46 (7.4%) | 30 (6.3%) | 5 (17.9%) | 14 (10.5%) | 42 (13.7%) |
| Other | 0 (0%) | 26 (4.2%) | 13 (2.7%) | 2 (7.1%) | 8 (6%) | 21 (6.9%) |
| Living alone | Male((p < 0.001) | | | Female ((p < 0.01) | | |
| yes | 83 (61.5%) | 286 (46.1%) | 175 (36.8%) | 15 (53.6%) | 30 (22.6%) | 70 (22.9%) |
| no | 52 (38.5%) | 334 (53.9%) | 301 (63.2%) | 13 (46.4%) | 103 (77.4%) | 236 (77.1%) |
| HIV-related knowledge level | Male(p = 0.02) | | | Female(P = 0.92) | | |
| inadequate knowledge | 48 (35.6%) | 269 (43.4%) | 169 (35.5%) | 8 (28.6%) | 41 (30.8%) | 97 (31.7%) |
| adequate knowledge | 87 (64.4%) | 351 (56.6%) | 307 (64.5%) | 20 (71.4%) | 92 (69.2%) | 208 (68%) |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.3%) |
| HIV risk perception | Male((p < 0.001) | | | Female ((p < 0.01) | | |
| No risk consideration | 61 (45.2%) | 365 (58.9%) | 351 (73.7%) | 14 (50%) | 82 (61.7%) | 226 (73.9%) |
| Concerned but optimistic bias | 74 (54.8%) | 255 (41.1%) | 125 (26.3%) | 14 (50%) | 51 (38.3%) | 80 (26.1%) |
| Motivation | Male((p < 0.001) | | | Female ((p < 0.001) | | |
| Curiosity, conformity and others | 18 (13.3%) | 138 (22.3%) | 99 (20.8%) | 10 (35.7%) | 17 (12.8%) | 100 (32.7%) |

| Variable | Class_1 | Class_2 | Class_3 | Class_1 | Class_2 | Class_3 |
|---|---|---|---|---|---|---|
| emotional needs | 16 (11.9%) | 53 (8.5%) | 93 (19.5%) | 7 (25%) | 36 (27.1%) | 119 (38.9%) |
| physical needs | 101 (74.8%) | 429 (69.2%) | 284 (59.7%) | 11 (39.3%) | 80 (60.2%) | 87 (28.4%) |
| HIV testing uptake | Male(p = 0.42) | | | Female(P = 0.76) | | |
| Never tested | 91 (67.4%) | 380 (61.3%) | 291 (61.1%) | 19 (67.9%) | 95 (71.4%) | 212 (69.3%) |
| Ever tested | 44 (32.6%) | 237 (38.2%) | 182 (38.2%) | 9 (32.1%) | 35 (26.3%) | 91 (29.7%) |
| Missing | 0 (0%) | 3 (0.5%) | 3 (0.6%) | 0 (0%) | 3 (2.3%) | 3 (1%) |
| Total | 135 (11%) | 620 (50.4%) | 476 (38.7%) | 28 (6%) | 133 (28.5%) | 306 (65.5%) |

**Factors Associated with Class Membership**

We fitted a multinomial logistic regression model on the overall sample (n = 1,698) to identify independent correlates between sociodemographic and HIV-related factors and latent class membership. Class 3 was set as the reference group (Table 4).

After covariate adjustment, several factors were significantly associated with membership in Class 1 relative to Class 3: male sex (OR = 2.69, 95%CI: 1.61–4.47), older age (70–79 vs. 50–59 years: OR = 0.53, 95%CI: 0.28–0.98; ≥80vs. 50–59 years: OR = 0.09, 95%CI: 0.01–0.68), lower educational level (junior high school vs. senior high school or above: OR = 2.33, 95%CI: 1.06–5.02; Primary school or less vs. senior high school or above: OR = 3.13, 95%CI: 1.41–6.95), higher monthly income (> 5000 RMB vs. <1000 RMB: OR = 3.54, 95%CI: 1.44–8.70), Commercial service staff (ref. farmer OR = 6.43, 95%CI: 2.93–14.10), living alone (OR = 2.63, 95% CI: 1.54–4.35), Optimistic bias (OR = 3.33, 95% CI: 2.25–4.91), never receiving HIV testing (OR = 1.56, 95% CI: 1.04–2.33).

For Class 2 versus Class 3, significant correlates included male sex (OR = 2.55, 95%CI: 1.95–3.34), advanced age (70–79 vs. 50–59 years: OR = 0.56, 95%CI: 0.39–0.82; ≥80vs. 50–59 years: OR = 0.43, 95%CI: 0.23–0.82), lower educational level (Primary school or less vs. senior high school or above: OR = 1.70, 95%CI: 1.11–2.59), higher monthly income (3001–5000 RMB vs. <1000 RMB: OR = 2.08, 95%CI: 1.35–3.23; 1001–3000 RMB vs. <1000 RMB: OR = 1.50, 95%CI: 1.15–1.96), living alone (OR = 1.72, 95% CI: 1.23–2.38), Poor HIV knowledge (OR = 1.32, 95% CI: 1.04–1.64), Optimistic bias (OR = 1.85, 95% CI: 1.45–2.35), Motives (emotional needs vs. curiosity and other motivations: OR = 0.57, 95%CI: 0.40–0.80; physical needs vs. curiosity and other motivations: OR = 1.48, 95%CI: 1.13–1.94).

# Gender-Stratified Multinomial Logistic Regression

Given inherent gender disparities in sexual risk behaviors and relevant correlates, we supplemented the pooled regression (adjusted for sex) with gender-stratified multinomial logistic models to derive separate effect estimates for males and females (Table 4). Class 3 was again the reference category.

**Among men** (mean age was 62 ± 8.6 years), membership in Class 1 (high-risk) was significantly associated with older age (≥ 80 vs. 50-59: OR = 0.1, 95% CI:0.1–0.8), lower educational level (Primary school or less vs. senior high school or above: OR = 2.99, 95%CI: 1.21–7.38), Unmarried (OR = 2.44, 95%CI: 1.18–5.06), higher monthly income (> 5000 RMB vs. <1000 RMB: OR = 4.63, 95%CI: 1.64–13.06), Commercial service staff (ref. farmer OR = 8.82, 95%CI: 3.22–24.18), living alone (OR = 2.38, 95% CI: 1.28–4.35), Optimistic bias (OR = 3.89, 95% CI: 2.48–6.12), never receiving HIV testing (OR = 1.92, 95% CI: 1.22–3.03).

In Class 2 was significantly associated with older age (70-79 vs. 50-59: OR = 0.52, 95% CI: 0.34–0.78; ≥80 vs. 50-59: OR = 0.37, 95% CI: 0.19–0.73;), lower educational level (Primary school or less vs. senior high school or above: OR = 2.13, 95%CI: 1.29–3.53), middle monthly income (3001–5000 RMB vs. <1000 RMB: OR = 2.35, 95%CI: 1.39–3.96; 1001–3000 RMB vs. <1000 RMB: OR = 1.64, 95%CI: 1.20–2.25), living alone (OR = 1.72, 95% CI: 1.16–2.56), moderate HIV knowledge (OR = 0.68, 95% CI: 0.52–0.89), Optimistic bias (OR = 1.98, 95% CI: 1.48–2.63), and emotional needs (OR = 0.4, 95% CI = 0.26–0.63).

**Among women** (mean age was 58.2 ± 6.3 years), the pattern was markedly different. Women in Class 1 were more likely to be younger (60-69 vs. 50-59: OR = 0.20, 95% CI: 0.05–0.81), living alone (OR = 3.70, 95% CI: 1.15–12.50), and Optimistic bias (OR = 2.85, 95% CI: 1.14–7.15). Within Class 2, divorced or widowed (OR = 0.51, 95% CI:0.26–0.97), Optimistic bias (OR = 1.76, 95% CI: 1.06–2.90), and more physical needs (OR = 5.75, 95% CI: 3.05–10.84) showed statistically significant associations with latent class allocation.

Table 4
Multinomial logistic regression of factors associated with latent class membership, overall and by gender

| Variable | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] |
|---|---|---|---|---|---|---|
| Class 1 vs Class 3 | | | | Class 2 vs Class 3 | | |
| Intercept | 0.03*** (0.01–0.08) | 0.06*** (0.02–0.20) | 0.02** (0.00-0.36) | 0.34*** (0.18–0.63) | | 0.18** (0.05–0.60) |
| Gender ref Female | | | | | | |
| Male | 2.69*** (1.61–4.47) | | | 2.55*** (1.95–3.34) | | |
| Age group(year) ref 50–59 | | | | | | |
| 60–69 | 0.78 (0.50–1.22) | 1.00 (0.61–1.65) | 0.20* (0.05–0.81) | 1.05 (0.81–1.36) | 1.06 (0.78–1.44) | 1.20 (0.70–2.05) |
| 70–79 | 0.53* (0.28–0.98) | 0.67 (0.34–1.30) | — | 0.56** (0.39–0.82) | 0.52** (0.34–0.78) | 1.07 (0.37–3.12) |
| ≥ 80 | 0.09* (0.01–0.70) | 0.10* (0.01–0.80) | — | 0.43** (0.23–0.82) | 0.37** (0.19–0.73) | 1.56 (0.07–32.94) |
| Household registration ref: local | | | | | | |
| non local | 1.52 (0.62–3.70) | 2.39 (0.77–7.43) | 0.69 (0.10–4.87) | 1.15 (0.62–2.13) | 1.36 (0.58–3.18) | 0.93 (0.33–2.61) |
| Educational level ref: senior high school or above | | | | | | |
| junior high school | 2.3* (1.06–5.02) | 1.80 (0.75–4.33) | 13.41 (1.05-171.01) | 1.48 (0.99–2.23) | 1.55 (0.96–2.51) | 1.14 (0.51–2.57) |
| Primary school or less | 3.13** (1.41–6.95) | 2.99* (1.21–7.38) | 10.20 (0.82-126.21) | 1.70* (1.11–2.59) | 2.13** (1.29–3.53) | 0.85 (0.37–1.93) |

| Variable | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] |
|---|---|---|---|---|---|---|
| Marital status ref: Married | | | | | | |
| Unmarried | 1.92 (1.01–3.64) | 2.44* (1.18–5.06) | 0.58 (0.09–3.81) | 0.92 (0.61–1.39) | 1.09 (0.68–1.75) | 0.43 (0.12–1.53) |
| Widowed or divorced | 1.40 (0.80–2.46) | 1.86 (0.95–3.62) | 1.23 (0.36–4.18) | 0.85 (0.61–1.19) | 1.11 (0.74–1.67) | 0.51* (0.26–0.97) |
| Monthly Income(RMB) ref: ≤1000 | | | | | | |
| 1001–3000 | 1.57 (1.01–2.46) | 1.74* (1.05–2.88) | 1.25 (0.40–3.87) | 1.34 (0.69–2.62) | 1.64** (1.20–2.25) | 1.22 (0.69–2.16) |
| 3001–5000 | 1.42 (0.66–3.08) | 1.39 (0.57–3.40) | 2.50 (0.44–14.23) | 2.08*** (1.35–3.23) | 2.35** (1.39–3.965) | 1.28 (0.52–3.14) |
| > 5000 | 3.54** (1.44–8.70) | 4.63** (1.64–13.06) | 1.68 (0.11–26.14) | 1.50** (1.15–1.96) | 1.49 (0.65–3.41) | 0.69 (0.19–2.44) |
| Occupation ref: Farmer | | | | | | |
| Worker | 0.96 (0.50–1.85) | 1.21 (0.58–2.51) | 0.22 (0.02–2.10) | 0.94 (0.63–1.41) | 1.08 (0.67–1.74) | 0.48 (0.20–1.16) |
| Retiree | 0.62 (0.22–1.79) | 0.53 (0.16–1.79) | 0.80 (0.07–9.63) | 0.78 (0.46–1.31) | 0.60 (0.31–1.16) | 0.81 (0.33–1.96) |
| Commercial service staff | 6.43*** (2.93–14.10) | 8.82*** (3.22–24.18) | 4.32 (0.98–19.10) | 1.76 (0.94–3.27) | 1.80 (0.80–4.05) | 2.16 (0.77–6.01) |
| Unemployed | 1.01 (0.48–2.14) | 0.79 (0.28–2.22) | 1.19 (0.36–3.99) | 1.20 (0.80–1.80) | 1.39 (0.82–2.34) | 0.84 (0.41–1.76) |
| Other | 0.44 | — | 1.62 | 1.24 | 1.60 | 0.71 |

| Variable | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] | OR(95% CI)[a] | OR(95% CI)[b] | OR(95% CI)[c] |
|---|---|---|---|---|---|---|
| | (0.10–1.99) | | (0.25–10.43) | (0.69–2.22) | (0.74–3.45) | (0.25–1.99) |
| Living alone ref: yes | | | | | | |
| no | 0.38*** (0.23–0.65) | 0.42** (0.23–0.78) | 0.27* (0.08–0.87) | 0.58*** (0.42–0.81) | 0.58** (0.39–0.86) | 0.91 (0.46–1.78) |
| HIV-related knowledge level ref: inadequate knowledge | | | | | | |
| adequate knowledge | 1.01 (0.68–1.51) | 0.89 (0.57–1.39) | 1.17 (0.43–3.22) | 0.76* (0.61–0.96) | 0.68** (0.52–0.89) | 1.22 (0.72–2.07) |
| HIV risk perception ref: No risk consideration | | | | | | |
| Concerned but optimistic bias | 3.33*** (2.25–4.91) | 3.89*** (2.48–6.12) | 2.85* (1.14–7.15) | 1.85*** (1.45–2.35) | 1.98*** (1.48–2.63) | 1.76* (1.06–2.90) |
| Motivation ref: Curiosity, conformity and others | | | | | | |
| emotional needs | 0.77 (0.41–1.45) | 0.86 (0.39–1.91) | 0.30 (0.09–0.99) | 0.57** (0.40–0.80) | 0.40*** (0.26–0.63) | 1.68 (0.86–3.30) |
| physical needs | 1.63 (1.00-2.66) | 1.62 (0.89–2.95) | 0.98 (0.34–2.85) | 1.48** (1.13–1.94) | 1.00 (0.73–1.38) | 5.75*** (3.05–10.84) |
| HIV testing uptake ref: never tested | | | | | | |
| Ever tested | 0.64* (0.43–0.96) | 0.52** (0.33–0.82) | 1.89 (0.71–5.05) | 0.95 (0.75–1.20) | 0.94 (0.71–1.23) | 0.69 (0.40–1.17) |

# Discussion

This study provides the first LCA-based characterization of sexual behavior patterns among Chinese adults aged ≥ 50 years with extramarital heterosexual encounters. Using item-response probabilities of the four behavioral indicators (partner type, number of sexual partners, condom use, and sexual frequency), we profiled three latent classes according to the most prevalent response category for each indicator within respective subgroups. These classes were subsequently labeled high-risk, moderate-risk,

and relatively low-risk. Our classification accords with prior research on sexual risk typologies and yields an empirically sound risk gradient consistent with the raw dataset [15].

Substantial disparities in risky sexual profiles were observed across the three latent classes. The high-risk class was defined by mixed commercial and non-commercial sexual partnerships, consistent with previous sexual network research which has empirically verified that sexual mixing serves as a critical risk factor for HIV transmission. The moderate-risk group predominantly engaged exclusively in commercial sex, whereas the relatively low-risk class was characterized mainly by non-commercial sexual encounters [16]. Notably, condom uptake remained extremely low across both commercial and non-commercial sexual activities among participants in the present study, which diverges from findings from a UK study focusing on HIV-related risk behaviors among male partners of female sex workers. The British research reported consistent condom use during most commercial sexual transactions. Such inconsistency may be attributable to disparities in demographic composition of study samples as well as divergent socioeconomic and cultural contexts between the two study populations [17].

The present survey indicated that older age, female gender, extremely low income and cohabitation were demographic characteristics associated with membership in the relatively low-risk latent class. In contrast, being male, unmarried, younger age, lower educational attainment, living alone, having sexual activity driven primarily by physical needs, and employment in commercial service industries constituted independent risk factors for moderate- and high-risk sexual behaviors. In addition, the risk level of sexual behaviors rose incrementally alongside increasing personal income. These findings partially account for the lower HIV infection prevalence observed among women compared with men, and the above demographic correlates are consistent with results from existing relevant studies.

Stratified multivariate logistic regression analyses by gender were further performed. Among females aged 50 years and older, age, educational attainment and occupation exerted no significant influence on the severity of risky sexual behaviors. For males, however, younger age, lower education, and employment in commercial service sectors were independent risk factors for moderate-to-high-risk sexual behaviors. In terms of marital status, married women were overrepresented in the moderate-risk class, whereas unmarried men predominated in the high-risk class. Severe marital pressure stemming from gender imbalance in the marriage market has resulted in a growing population of involuntarily single men [18, 19]. Constrained by such circumstances, these men resort to extramarital sexual activities, which in turn elevates their risk of HIV infection [20]. Conversely, among women may be attributed to low relationship happiness, which drives married women to engage in extramarital sexual activities [21]. Stratified by income, elevated income was correlated with higher-risk sexual behaviors only among men, while no significant income-related disparity was observed in women. Such discrepancy may be explained by gender-based differences in economic exchange during sexual encounters. Specifically, men generally bear financial costs for extramarital sexual relations (whether commercial or non-commercial), whereas women tend to receive economic compensation [22].

To our knowledge, the overrepresentation of men in commercial service occupations within the high-risk group has not been reported in previous studies. This finding, if replicated in future research, may suggest that occupational environments facilitating social mixing and access to entertainment venues deserve greater attention in HIV prevention efforts targeting older men.

Living alone was associated with moderate- and high-risk class membership in both sexes. The absence of daily surveillance may increase opportunity for non-marital encounters, while social isolation may amplify unmet intimacy needs[4]. The cross-gender consistency suggests a structural rather than gender-specific pathway, making living arrangement a practical marker for targeted prevention.

Intriguingly, our analysis reveals that men with insufficient HIV-related knowledge were overrepresented in the moderate-risk pattern compared to the low-risk pattern, whereas no such clustering was observed among those in the high-risk pattern. This divergent distribution may be explained by a polarized behavioral pattern among men with moderate HIV literacy: moderate-risk men equipped with HIV knowledge will avoid moderate-risk sexual behaviors and switch to low-risk practices; in contrast, high-risk men tend to downplay HIV risks and persist in high-risk sexual behaviors out of risk-taking mentality regardless of their HIV knowledge level. These findings indicate that routine health education barely induces behavioral modification among high-risk populations. Therefore, tiered and differentiated health promotion and intervention packages tailored to distinct sexual risk profiles should be developed, which also accounts for the suboptimal effectiveness of current universal HIV prevention interventions. A study focusing on gay, bisexual, and other men who have sex with men found that despite sustained improvements in the awareness of HIV-related knowledge, the prevalence of condomless sex remained persistently high [23]. This finding is partially inconsistent with the results of the present study. The discrepancy may stem from differences in the study populations, or it could be attributed to the absence of further stratified analyses based on varying levels of sexual risk behaviors in that research.

Findings from a cross-sectional survey of adults aged 50 years and older in South Africa indicated that older adults who perceived a high personal risk of HIV infection were generally sexually active [24]. Our study further revealed that participants who acknowledged HIV risks yet harbored a risk-taking mentality were more likely to fall into the medium- and high-risk subgroups compared with those who never perceived any HIV exposure risk. Accordingly, risk-taking mentality may constitute the primary barrier to behavioral modification among populations engaging in high-risk sexual behaviors.

Our findings challenge conventional gender scripts: women in the commercial-sex-oriented moderate-risk group reported physiological needs as primary, while men in the non-commercial low-risk group reported emotional needs. This dual inversion suggests sexual motivation is context-dependent rather than gender-fixed. For women, transactional contexts may legitimize physiological expression without emotional engagement; for men, non-commercial contexts may permit emotional articulation otherwise discouraged by masculinity norms. These patterns challenge current HIV prevention assumptions—that men are risk-takers needing correction and women passive recipients needing

empowerment. Instead, interventions should address men's emotional needs and women's sexual agency, moving beyond generic sex education to motivationally informed, context-sensitive approaches.

In terms of HIV testing behavior, individuals in the high-risk group did not exhibit higher testing coverage. On the contrary, men with high-risk sexual behaviors were more likely to have never undergone HIV testing. These findings indicate that the current routine HIV screening strategies fail to effectively target populations engaging in high-risk sexual behaviors. Future comprehensive interventions should incorporate distinct behavioral characteristics and associated influencing factors across different risk subgroups to develop more precise and targeted HIV prevention and control strategies.

**Limitations**

This study has several limitations. First, convenience sampling was adopted, which may introduce inherent sampling bias. Non-commercial extramarital sexual behaviors among older adults are highly concealed, and such hidden high-risk populations are difficult to reach and recruit through routine survey approaches. Accordingly, the sample may fail to fully cover individuals with diverse behavioral characteristics, limiting sample representativeness. Second, due to the widespread social stigma surrounding non-marital and commercial sexual behaviors in older adults, self-reported information on sexual behaviors and motivations is susceptible to social desirability bias and reporting bias. Third, the study was conducted in specific regional settings; thus, the findings cannot be readily generalized to the national middle-aged and older adult population. Fourth, the cross-sectional design only allows for the analysis of correlational associations rather than causal relationships. In addition, questionnaire-based measurements cannot fully capture complex and long-term psychological factors related to sexual risk-taking.

**Implications**: This study provides targeted implications for HIV prevention among older adults in China:

1. 1. Implement stratified and tailored risk interventions. Three distinct sexual risk subgroups were identified among older adults, indicating the limited applicability of conventional universal health education. Individualized interventions should be delivered based on risk stratification. Furthermore, targeted training on safer sex practices is urgently needed given the consistently low condom use across all subgroups. Notably, living alone is a common structural risk factor for sexual risk behaviors among older adults of all genders and warrants enhanced intervention attention.
2. 2. Adopt gender-differentiated prevention strategies. Male high-risk sexual behaviors were significantly associated with sociodemographic factors including age, education, occupation, income, and marital status, whereas female sexual risk was largely independent of socioeconomic characteristics. Unlike previous studies that primarily focused on unmarried individuals as high-risk populations, this study highlights the hidden risk among married older women, whose extramarital risky behaviors may stem from low marital satisfaction.
3. 3. Strengthen targeted interventions on risk cognition and sexual motivation. Optimistic bias is a key barrier to behavioral modification. Correcting risk perception bias is more effective than simply disseminating HIV-related knowledge. The context-dependent gender-reversed pattern of sexual

motivation identified in this study challenges traditional gender stereotypes. Future interventions should accommodate older men's emotional needs, respect women's sexual agency, and alleviate women's economic disadvantages.

4. 4. Optimize targeted HIV screening strategies. Current screening approaches fail to accurately identify and cover hidden high-risk older adults. It is necessary to reform passive screening models and develop precise, scenario-based screening strategies tailored to the behavioral characteristics of elderly high-risk groups to improve insufficient testing coverage among at-risk populations.

## Conclusions

This is the first study to identify three heterogeneous latent sexual risk subgroups, namely mixed high-risk, commercial sex-dominated moderate-risk, and non-commercial low-risk groups, among Chinese adults aged 50 years and older. Condom use was universally low across all subgroups. living alone serves as a common risk factor for elevated sexual risk among older adults regardless of gender. Significant gender disparities existed in other risk determinants: male sexual risk was closely linked to socioeconomic profiles, marital status, and occupational and residential characteristics, while female sexual risk was not affected by sociodemographic factors.

Notably, married older women represent a neglected high-risk subgroup, with poor marital quality potentially contributing to their extramarital risky behaviors. HIV-related knowledge showed protective effects only for men, consistent with their dominant role in sexual decision-making, while optimistic bias severely hinders behavioral change. Sexual motivation is context-dependent rather than inherently determined by gender. Tailored, gender-differentiated, and motivation-targeted interventions, together with optimized precise screening strategies, are essential to reduce HIV transmission among older adults in China.

## Abbreviations

AIC
Akaike information criterion
AIDS
Acquired Immunodeficiency Syndrome
CI
confidence interval
BIC
Bayesian information criterion
HIV
Human Immunodeficiency Virus
LCA
Latent class analysis
OR

Odds ratio
RMB
Renminbi

## Declarations

### Ethics approval and consent to participate

This study was approved by the Institutional Review Board, National Center for AIDS/STD Control and Prevention, Chinese Center for Disease Control and Prevention, Protocol No. X231018760. All participants provided written informed consent before participation. The study was conducted in accordance with the Declaration of Helsinki.

### Consent for publication

Not applicable. This manuscript does not contain any individual person's identifiable data or images.

## Competing interests

The authors declare that they have no competing interests.

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## Author Contribution

JY contributed to conceptualization, methodology, formal analysis, writing – original draft, and funding acquisition. JL, LL, JC, YB, SL, LW, CZ, HJ, LF, CX, HC, and SD contributed to investigation, data curation, and project administration. PX contributed to supervision, resources, and funding acquisition. ML contributed to investigation. YL contributed to conceptualization, supervision, and writing – review and editing. All authors read and approved the final manuscript.

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# Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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