Preplanned Studies

An Index–Contact Paired Data Analysis on Sexual Contact Tracing Outcomes of HIV-Infected Individuals — Yunnan Province, China, 2022–2024

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Summary

What is already known about this topic?

A substantial proportion of people living with human immunodeficiency virus (PLWH) remain unaware of their infection status. Contact tracing serves as an effective public health tool for identifying human immunodeficiency virus (HIV) infections and supports progress toward achieving the 95-95-95-95 goals.

What is added by this report?

An egocentric contact tracing study conducted in Yunnan, China, between January 2022 and June 2024 enrolled 1,981 index cases, of whom 314 (15.9%) had at least 1 HIV-positive sexual contact. These index cases reported 2,171 sexual contacts, with 1,509 (69.5%) receiving HIV testing and 317 (21.0%) testing positive. Higher education levels and employment status among sexual contacts were positively associated with HIV testing uptake. HIV infection was more likely among contacts when the index case was female and identified through active HIV testing. Long-term sexual partnerships and inconsistent condom use demonstrated elevated infection risk.

What are the implications for public health practice?

The effectiveness of contact tracing outcomes is influenced by characteristics of both index cases and their sexual contacts. These factors should be incorporated into the design and implementation of sexual contact tracing programs.

Despite numerous innovative interventions, achieving the second 95 target [95% of people living with human immunodeficiency virus (PLWH) know their human immunodeficiency virus (HIV) status] set by the Joint United Nations Programme on HIV and AIDS (UNAIDS) remains challenging (*1*). In China, approximately 20% of PLWH were estimated to be unaware of their infection status in 2020 (*2*), with more than 40% of HIV-infected individuals receiving diagnoses at advanced stages of infection (*3*). This late diagnosis pattern leads to poorer clinical outcomes and impedes efforts to control HIV transmission (*4*). Contact tracing has emerged as a promising strategy for controlling the spread of infectious diseases (*5*–*7*). While previous research has primarily focused on examining associations between contact characteristics and tracing outcomes, the intimate nature of HIV transmission suggests that incorporating index case characteristics could provide crucial insights into understanding transmission networks within populations (*8*). To enhance and optimize contact tracing strategies, we conducted an egocentric contact tracing study from 2022 to 2024 in Yunnan, China. Our findings demonstrate that both index case and sexual contact characteristics significantly influence sexual contact tracing outcomes. These results suggest that interventions leveraging these facilitating factors offer promising pathways toward achieving the UNAIDS targets.

This egocentric contact tracing survey was conducted between January 2022 and June 2024 in Honghe Hani and Yi Autonomous Prefecture (Honghe Prefecture) of Yunnan Province, China. Newly diagnosed HIV-infected individuals aged 18 years or older who could provide sexual contact information were eligible and invited to participate as index cases. After providing informed consent, participants were interviewed by trained local health specialists using an anonymous questionnaire with unique identification numbers linking index cases. Interviews were conducted in private rooms where participants provided detailed information about their individual characteristics and all sexual partners with whom they had engaged in sexual intercourse. Index cases were subsequently encouraged to notify their sexual partners and refer them for HIV counseling and testing. Sexual contacts who tested HIV-positive were invited to

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participate as new index cases in subsequent rounds of contact tracing. This iterative process continued until either no additional HIV-positive contacts were identified or no further sexual contacts could be traced. The study protocol was approved by the Ethics Committee of Yunnan Center for Disease Control and Prevention (Permit Number: YNCDC/QR-KJB-2021-003).

Contact tracing outcomes were classified as "successful" when at least one HIV-positive sexual partner was identified from an index HIV case. Testing modalities were categorized as either active, defined as HIV testing at a voluntary counseling and testing (VCT) clinic, or passive, which included all other identification pathways [e.g., provider-initiated testing and counseling (PITC)]. Data analysis was conducted at both index case and contact levels. At the index case level, bivariate and multivariate logistic regression analyses evaluated associations between index case characteristics and tracing outcomes. At the contact level, index–contact paired data were analyzed using multilevel logit models to assess relationships between both index case and contact factors related to HIV testing uptake and infection status among sexual contacts. All statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA) with a significance level of 0.05.

The contact tracing process and identification of HIV infections are detailed in Supplementary Table S1 and Figure S1 (available at https://weekly.chinacdc.cn/). Among 1,981 enrolled index cases (1,925 newly reported during the study period, 54 identified from first-round contact tracing, and 2 from second-round), a total of 2,171 sexual contacts were reported, with a mean of 1.1 partners per index case (range: 1–4) and a median of 1 partner. Of these contacts, 69.5% (1,509/2,171) underwent HIV testing, with 21.0% (317/1,509) testing positive. The sexual network index (*9*) (contacts recruited per HIV-infected index case) was 0.8 (1,509/1,981). In the first round, 1,925 index cases reported 2,097 contacts, of whom 1,474 were tested and 308 were positive. Of these positive contacts, 54 participated as second-round index cases, reporting 69 contacts, with 32 tested and 9 positive. In the third round, 2 of the 9 positive contacts participated as index cases, reporting 5 contacts, of whom 3 were tested with no positive results.

The demographic profile of index cases showed a predominance of male individuals, aged 36–55 years, from ethnic minority backgrounds, with primary school education or less, who were married and employed. Notably, 85% were identified through passive testing, and approximately 35% presented with CD4 counts ≤200 cells per microliter at baseline. Sexual contacts were predominantly female (>50%), aged 36–55 years, from ethnic minorities, with primary school education or less, and employed. Most contacts were married, with approximately half engaged in non-marital, non-commercial sexual partnerships with their index case. The majority of relationships (71.9%) were of 1 year or less duration, with nearly 65% reporting sexual contact once or twice weekly in the previous 6 months. Condom use was notably low, with 65.8% reporting never using condoms during sexual encounters with their index case. Significant differences between index cases and sexual contacts were observed across gender, age, ethnicity, education, and marital status (Supplementary Table S2, available at https://weekly.chinacdc.cn/).

The success rate of tracing HIV-positive sexual contacts varied significantly by index case characteristics, with notably higher rates among female and married index cases. Additionally, index cases identified through active testing methods demonstrated superior contact tracing outcomes (Table 1).

Multivariate analysis revealed that sexual contacts of ethnic minorities, those with higher educational attainment, and employed individuals demonstrated increased likelihood of HIV testing uptake. Testing rates were notably higher among spouses and long-term partners, those in established relationships, individuals reporting frequent sexual activity, and those practicing consistent condom use. The probability of HIV infection was significantly elevated among contacts whose index case was female and identified through active testing protocols. Additionally, established relationships, particularly among spouses and long-term partners, exhibited higher infection rates compared to temporary or commercial relationships. HIV positivity was markedly increased among individuals reporting inconsistent or no condom use versus those maintaining consistent condom use practices (Table 2).

DISCUSSION

Our egocentric contact tracing study revealed a 21.0% positive detection rate, substantially higher than conventional screening methods such as PITC (0.2%) and VCT (4.2%) (*10*). This elevated efficiency in

TABLE 1. Association between sociodemographic and behavioral characteristics and sexual contact tracing outcomes among index HIV cases in Honghe Prefecture, Yunnan Province, China 2022–2024.

Characteristic	Index, *N*=1,981	Traced, *N*=314		Bivariate		Multivariate	
		n	*%**	*cOR*	*95% CI*	*aOR*	*95% CI*
Sex							
Male	1,350	116	8.6	1.0		1.0	
Female	631	198	31.4	**4.9**	**3.8, 6.3**	**4.7**	**3.6, 6.2**
Age							
18–35 years	378	46	12.2	1.0		1.0	
36–55 years	1,062	175	16.5	**1.4**	**1.0, 2.0**	1.1	0.7, 1.7
≥56 years	541	93	17.2	**1.5**	**1.0, 2.2**	1.2	0.7, 1.9
Ethnicity							
Han	728	116	15.9	1.0		1.0	
Ethnic minorities	1,253	198	15.8	1.0	0.8, 1.3	0.9	0.7, 1.2
Education							
≤Primary school	1,248	216	17.3	1.0		1.0	
Junior high school	512	70	13.7	0.8	0.6, 1.0	0.9	0.6, 1.2
≥Senior high school	221	28	12.7	0.7	0.5, 1.1	0.8	0.5, 1.4
Marital status							
Never married	506	42	8.3	1.0		1.0	
Currently married	863	175	20.3	**2.8**	**2.0, 4.0**	**1.6**	**1.1, 2.5**
Divorced or widowed	612	97	15.9	**2.1**	**1.4, 3.1**	1.1	0.7, 1.8
Occupation							
Unemployed	320	53	16.6	1.0		1.0	
Employed	1,661	261	15.7	0.9	0.7, 1.3	0.9	0.6, 1.3
Type of HIV testing							
Passive testing	1,684	222	13.2	1.0		1.0	
Active testing	297	92	31.0	**3.0**	**2.2, 3.9**	**3.1**	**2.2, 4.2**
CD4 counts at baseline (cells/microliter)							
≤200	695	92	13.2	1.0		1.0	
201–350	587	92	15.7	1.2	0.9, 1.7	1.0	0.8, 1.5
351–500	359	59	16.4	1.3	0.9, 1.8	1.0	0.7, 1.5
≥501	301	67	22.3	**1.9**	**1.3, 2.7**	1.3	0.9, 1.9
Unknown	39	4	10.3	0.7	0.3, 2.2	0.8	0.2, 2.4

Note: bolded denotes *P*<0.05.

Abbreviation: HIV=human immunodeficiency virus; *cOR*=crude odds ratio; *aOR*=adjusted odds ratio; *CI*=confidence interval.

* Refers to the efficacy of contact tracing: the probability of successfully tracing other positive cases through the index case, which is calculated as the number of index cases with HIV-positive contacts divided by total index cases.

identifying HIV infections compared to routine practices underscores the value of sexual contact tracing as a targeted intervention strategy. Our findings also highlight how the characteristics of both index cases and their sexual contacts significantly influence contact tracing outcomes, suggesting the need for these factors to be incorporated into program design.

The success of sexual contact tracing was notably influenced by specific characteristics of index cases. Female index cases demonstrated superior tracing outcomes compared to their male counterparts. This gender disparity may be attributed to male index cases often having multiple partners, potentially compromising their ability to accurately recall contact details and leading to tracing failures (*11*–*12*). Additionally, index cases identified through active HIV testing showed improved tracing results compared to those detected passively, consistent with previous

TABLE 2. HIV testing and infection among sexual contacts by sociodemographic and behavioral characteristics in Honghe Prefecture, Yunnan Province, China, 2022–2024.

Characteristic	Contacts *N*=2,171	Tested *N*=1,509 (%)*	Positive *N*=317 (%)†	Tested *vs.* untested		Positive *vs.* negative	
				cOR (95% *CI*)	*aOR* (95% *CI*)	*cOR* (95% *CI*)	*aOR* (95% *CI*)
Index							
Sex							
Male	1,487	990 (66.6)	113 (11.4)	1.0	1.0	1.0	1.0
Female	684	519 (75.9)	204 (39.3)	**1.6 (1.3, 1.9)**	1.0 (0.7, 1.5)	**5.0 (3.9, 6.5)**	**2.6 (1.3, 5.3)**
Age							
18–35 years	420	301 (71.7)	46 (15.3)	1.0	1.0	1.0	1.0
36–55 years	1,158	784 (67.7)	179 (22.8)	0.8 (0.6, 1.1)	0.8 (0.5, 1.1)	**1.6 (1.1, 2.3)**	0.7 (0.4, 1.4)
≥56 years	593	424 (71.5)	92 (21.7)	1.0 (0.8, 1.3)	1.0 (0.7, 1.6)	**1.5 (1.0, 2.3)**	0.7 (0.3, 1.5)
Ethnicity							
Han	795	548 (68.9)	116 (21.2)	1.0	1.0	1.0	1.0
Ethnic minorities	1,376	961 (69.8)	201 (20.9)	1.0 (0.9, 1.3)	0.8 (0.6, 1.0)	1.0 (0.8, 1.3)	0.7 (0.5, 1.1)
Education							
≤Primary school	1,364	954 (69.9)	221 (23.2)	1.0	1.0	1.0	1.0
Junior high school	561	388 (69.2)	70 (18.0)	1.0 (0.8, 1.2)	1.0 (0.8, 1.3)	0.7 (0.5, 1.0)	0.9 (0.6, 1.5)
≥Senior high school	246	167 (67.9)	26 (15.6)	0.9 (0.7, 1.2)	0.9 (0.6, 1.4)	0.6 (0.4, 1.0)	0.6 (0.3, 1.2)
Marital status							
Never married	554	368 (66.4)	38 (10.3)	1.0	1.0	1.0	1.0
Currently married	948	691 (72.9)	181 (26.2)	**1.4 (1.1, 1.7)**	1.0 (0.8, 1.4)	**3.1 (2.1, 4.5)**	0.7 (0.4, 1.3)
Divorced or widowed	669	450 (67.3)	98 (21.8)	1.0 (0.8, 1.3)	1.0 (0.7, 1.4)	**2.4 (1.6, 3.6)**	1.0 (0.6, 2.0)
Occupation							
Unemployed	349	238 (68.2)	52 (21.9)	1.0	1.0	1.0	1.0
Employed	1,822	1,271 (69.8)	265 (20.9)	1.1 (0.8, 1.4)	1.1 (0.8, 1.5)	0.9 (0.7, 1.3)	0.7 (0.4, 1.2)
Type of HIV testing							
Passive testing	1,841	1,267 (68.8)	223 (17.6)	1.0	1.0	1.0	1.0
Active testing	330	242 (73.3)	94 (38.8)	1.2 (1.0, 1.6)	1.1 (0.8, 1.4)	**3.0 (2.2, 4.0)**	**3.1 (2.0, 4.8)**
CD4 counts at baseline (cells/microliter)							
≤200	760	515 (67.8)	89 (17.3)	1.0	1.0	1.0	1.0
201–350	634	431 (68.0)	92 (21.4)	1.0 (0.8, 1.3)	0.9 (0.7, 1.2)	1.3 (0.9, 1.8)	1.1 (0.7, 1.8)
351–500	402	291 (72.4)	62 (21.3)	1.2 (1.0, 1.6)	1.2 (0.9, 1.6)	1.3 (0.9, 1.9)	1.1 (0.7, 1.8)
≥501	333	244 (73.3)	70 (28.7)	1.3 (1.0, 1.7)	1.1 (0.8, 1.5)	**1.9 (1.3, 2.8)**	1.2 (0.7, 2.1)
Unknown	42	28 (66.7)	4 (14.3)	1.0 (0.5, 1.8)	0.9 (0.4, 1.9)	0.8 (0.3, 2.4)	1.2 (0.3, 5.4)
Contacts							
Sex of contacts							
Female	1,327	894 (67.4)	106 (11.9)	1.0	1.0	1.0	1.0
Male	844	615 (72.9)	211 (34.3)	**1.3 (1.0, 1.6)**	0.9 (0.6, 1.3)	**3.9 (2.8, 5.5)**	1.7 (0.7, 4.4)
Age of contacts							
<18 years	19	14 (73.7)	2 (14.3)	1.0	1.0	1.0	1.0
18–35 years	809	526 (65.0)	71 (13.5)	0.7 (0.2, 1.9)	0.7 (0.2, 2.3)	0.9 (0.2, 4.7)	0.6 (0.1, 4.8)
36–55 years	1,089	776 (71.3)	170 (21.9)	0.9 (0.3, 2.5)	1.1 (0.3, 3.7)	1.7 (0.3, 8.3)	0.6 (0.1, 4.9)
≥56 years	254	193 (76.0)	74 (38.3)	1.1 (0.4, 3.3)	1.0 (0.3, 3.7)	3.7 (0.7, 18.7)	0.6 (0.1, 5.2)

Continued

Characteristic	Contacts *N*=2,171	Tested *N*=1,509 (%)*	Positive *N*=317 (%)†	Tested *vs.* untested		Positive *vs.* negative	
				cOR (95% *CI*)	*aOR* (95% *CI*)	*cOR* (95% *CI*)	*aOR* (95% *CI*)
Ethnicity of contacts							
Han	1,030	653 (63.4)	128 (19.6)	1.0	1.0	1.0	1.0
Ethnic minorities	1,141	856 (75.0)	189 (22.1)	**1.7 (1.4, 2.1)**	**1.8 (1.4, 2.4)**	1.2 (0.9, 1.5)	1.1 (0.7, 1.8)
Education of contacts							
≤Primary school	1,432	980 (68.4)	211 (21.5)	1.0	1.0	1.0	1.0
Junior high school	592	423 (71.5)	84 (19.9)	1.2 (0.9, 1.4)	**1.6 (1.2, 2.1)**	0.9 (0.7, 1.2)	0.9 (0.5, 1.4)
≥Senior high school	147	106 (72.1)	22 (20.8)	1.2 (0.8, 1.8)	**2.2 (1.3, 3.9)**	1.0 (0.6, 1.6)	0.9 (0.4, 2.1)
Marital status of contacts							
Never married	651	427 (65.6)	48 (11.2)	1.0	1.0	1.0	1.0
Currently married	775	582 (75.1)	185 (31.8)	**1.6 (1.3, 2.0)**	0.8 (0.6, 1.2)	**3.7 (2.6, 5.3)**	1.2 (0.6, 2.4)
Divorced or widowed	745	500 (67.1)	84 (16.8)	1.1 (0.9, 1.3)	0.9 (0.7, 1.2)	**1.6 (1.1, 2.4)**	1.5 (0.8, 2.9)
Occupation of contacts							
Unemployed	309	159 (51.5)	29 (18.2)	1.0	1.0	1.0	1.0
Employed	1,862	1350 (72.5)	288 (21.3)	**2.5 (1.9, 3.2)**	**2.3 (1.7, 3.2)**	1.2 (0.7, 2.0)	0.8 (0.4, 1.8)
Type of sexual relationship with index case							
Commercial sexual partnership	681	400 (58.7)	25 (6.3)	1.0	1.0	1.0	1.0
Spouse or long-term sexual partnership	375	358 (95.5)	185 (51.7)	**14.8 (8.8, 24.8)**	**12.7 (6.8, 23.6)**	**16.0 (10.0, 25.7)**	**2.3 (1.1, 4.6)**
Non-marital and non-commercial sexual partnership	1,115	751 (67.4)	107 (14.3)	**1.4 (1.2, 1.8)**	1.1 (0.8, 1.4)	**2.5 (1.6, 4.0)**	0.8 (0.4, 1.6)
Duration of sexual relationship with index case							
≤1 years	1,560	1,004 (64.4)	76 (7.6)	1.0	1.0	1.0	1.0
1–3 years	200	159 (79.5)	57 (35.9)	**2.1 (1.5, 3.1)**	**1.6 (1.0, 2.4)**	**6.8 (4.5, 10.3)**	**5.4 (3.2, 9.3)**
>3 years	411	346 (84.2)	184 (53.2)	**2.9 (2.2, 3.9)**	0.9 (0.6, 1.4)	**13.9 (10.0, 19.2)**	**7.1 (4.2, 12.2)**
Frequency of sexual behavior with index case in the past 6 months							
<once a week	554	327 (59.0)	48 (14.7)	1.0	1.0	1.0	1.0
1–2 times a week	1,379	985 (71.4)	225 (22.8)	**1.7 (1.4, 2.1)**	**1.6 (1.3, 2.1)**	**1.7 (1.2, 2.5)**	1.5 (0.9, 2.4)
≥3 times a week	238	197 (82.8)	44 (22.3)	**3.3 (2.3, 4.9)**	**3.3 (2.1, 5.1)**	**1.7 (1.0, 2.7)**	1.7 (0.8, 3.4)
Frequency of condom use with index case in the past 6 months							
Never	1,428	980 (68.6)	229 (23.4)	1.0	1.0	**20.3 (6.1, 68.0)**	**31.1 (7.6, 128.0)**
Inconsistently	506	326 (64.4)	85 (26.1)	0.8 (0.7, 1.0)	0.8 (0.6, 1.0)	**23.5 (6.9, 80.0)**	**31.9 (7.6, 133.7)**
Consistently	237	203 (85.7)	3 (1.5)	**2.7 (1.9, 4.0)**	**3.9 (2.5, 5.9)**	1.0	1.0

Note: bolded denotes *P*<0.05.
Abbreviation: HIV= human immunodeficiency virus; *cOR*= crude odds ratio; *aOR*= adjusted odds ratio; *CI*=confidence interval.
* Refers to HIV testing rate: the number of contacts tested for HIV as a percentage of total contacts.
† Refers to HIV positivity rate: the number of contacts tested positive as a percentage of total contacts tested for HIV.

research (*13*). This pattern likely reflects the heightened health awareness among individuals who proactively seek HIV testing through VCT clinics. These findings emphasize that the characteristics of index HIV cases are crucial considerations in optimizing contact tracing strategies.

Our index-contact paired data analysis revealed that HIV testing uptake among contacts was primarily influenced by the contacts' characteristics. Sexual contacts with higher educational attainment and employment status demonstrated increased testing rates, likely attributable to enhanced health literacy (*14*). Relationship dynamics played a crucial role, with long-term and stable partners showing higher testing

rates compared to commercial partners, aligning with previous findings in China (*9*). This pattern underscores the efficiency of contact tracing strategies, particularly among these high-risk populations. Moreover, frequent sexual activity and consistent condom use were positively associated with HIV testing rates, suggesting that individuals who engage in regular sexual activity while practicing safe sex may have a heightened awareness of HIV risk and greater motivation to know their status. These findings emphasize that improving accessibility and acceptability of HIV testing services could significantly enhance screening uptake (*15*).

The likelihood of HIV infection among sexual contacts was influenced by both contact characteristics and index case factors. Contacts had higher infection rates when their index case was female and identified through active testing protocols. Long-term and stable partnerships also demonstrated elevated infection risks. The higher detection rate among partners of female index cases may be attributed to women typically having fewer sexual contacts, though further research is needed to elucidate the underlying mechanisms. The prevalence of inconsistent condom use emerged as a significant factor in HIV transmission between partners. Evidence suggests that comprehensive intervention programs integrating condom promotion with testing services yield superior outcomes compared to isolated health education initiatives (*16*). These integrated approaches are fundamental to advancing both HIV prevention and testing outcomes.

This study has several important limitations that warrant consideration. First, as the research was conducted in a single prefecture of Yunnan Province, the generalizability of our findings to other regions remains uncertain. Second, the use of convenience sampling may have introduced selection bias, potentially limiting the representativeness of our study population. Third, the reliance on index cases to provide information about their sexual contacts may have introduced information bias through recall errors, social desirability bias, or deliberate omission of contact details.

Despite these methodological constraints, our findings provide compelling evidence for the feasibility and effectiveness of contact tracing as a strategy for identifying HIV infections. The results illuminate critical factors that could enhance sexual contact tracing outcomes. Future research should build upon these findings by developing and evaluating targeted strategies that address both index cases and their sexual partners simultaneously.

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REFERENCES

1. Global HIV Statistics. Global HIV & AIDS statistics — fact sheet. 2024. https://www.unaids.org/en/resources/fact-sheet. [2024-8-1].
2. Zhao Y, Han MJ, Ma Y, Li DM. Progress towards the 90-90-90 targets for controlling HIV — China, 2018. China CDC Wkly 2019;1(1):5 – 7. https://doi.org/10.46234/ccdcw2019.003.
3. Sun CQ, Li JJ, Liu XY, Zhang Z, Qiu T, Hu HY, et al. HIV/AIDS late presentation and its associated factors in China from 2010 to 2020: a systematic review and meta-analysis. AIDS Res Ther 2021;18(1):96. https://doi.org/10.1186/s12981-021-00415-2.
4. Waters L, Sabin CA. Late HIV presentation: epidemiology, clinical implications and management. Expert Rev Anti Infect Ther 2011;9 (10):877 – 89. https://doi.org/10.1586/eri.11.106.
5. Oh MK, Boker JR, Genuardi FJ, Cloud GA, Reynolds J, Hodgens JB. Sexual contact tracing outcome in adolescent chlamydial and gonococcal cervicitis cases. J Adolesc Health 1996;18(1):4 – 9. https://doi.org/10.1016/1054-139X(95)00109-6.
6. Christie TKS, Kendall P. The science of partner notification: a review of the available evidence. BC Med J 2003;45(3):124-7. https://bcmj.org/articles/science-partner-notification-review-available-evidence.
7. Centers for Disease Control and Prevention. Current trends partner notification for preventing human immunodeficiency virus (HIV) infection -- Colorado, Idaho, South Carolina, Virginia. 2001. https://www.cdc.gov/mmwr/preview/mmwrhtml/00000042.htm. [2024-7-28].
8. Klovdahl AS. Social networks and the spread of infectious diseases: the AIDS example. Soc Sci Med 1985;21(11):1203 – 16. https://doi.org/10.1016/0277-9536(85)90269-2.
9. Lin HJ, He N, Ding YY, Qiu DH, Zhu WM, Liu X, et al. Tracing sexual contacts of HIV-infected individuals in a rural prefecture, Eastern China. BMC Public Health 2012;12:533. https://doi.org/10.1186/1471-2458-12-533.
10. Han Y, An XJ, Ma YL, Huo JL, Zhang XB, Yang ZM, et al. Exploration and practice of HIV contact tracing strategy in Yunnan Province. Chin J AIDS STD 2022;28(7):852-4. http://dx.doi.org/10.13419/j.cnki.aids.2022.07.23. (In Chinese).
11. Maierhofer CN, Powers KA, Matoga MM, Chen JS, Jere E, Massa C, et

al. Characterizing network-based HIV testing interventions to guide HIV testing and contact tracing at STI clinics in Lilongwe, Malawi. J Acquir Immune Defic Syndr 2023;94(2):151 – 9. https://doi.org/10.1097/QAI.0000000000003240.
12. Parish WL, Laumann EO, Mojola SA. Sexual behavior in China: trends and comparisons. Popul Dev Rev 2007;33(4):729 – 56. https://doi.org/10.1111/j.1728-4457.2007.00195.x.
13. Hong H, Zhang DD, Jiang HB, Shi HB, Tan SW, Gu WZ, et al. HIV infection and related factors of traceability efficiency among sex partners of HIV positive men who have sex with men. Chin J Epidemiol 2021;42(12):2100 – 5. https://doi.org/10.3760/cma.j.cn112338-20210811-00632.
14. Wawrzyniak AJ, Ownby RL, McCoy K, Waldrop-Valverde D. Health literacy: impact on the health of HIV-infected individuals. Curr HIV/AIDS Rep 2013;10(4):295 – 304. https://doi.org/10.1007/s11904-013-0178-4.
15. Sundararajan R, Ponticiello M, Nansera D, Jeremiah K, Muyindike W. Interventions to increase HIV testing uptake in global settings. Curr HIV/AIDS Rep 2022;19(3):184 – 93. https://doi.org/10.1007/s11904-022-00602-4.
16. Chow EPF, Tung K, Tucker JD, Muessig KE, Su S, Zhang XH, et al. Behavioral interventions improve condom use and HIV testing uptake among female sex workers in China: a systematic review and meta-analysis. AIDS Patient Care STDS 2015;29(8):454 – 60. https://doi.org/10.1089/apc.2015.0043.

SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Rounds of tracing of sexual contacts for index HIV cases in Honghe Prefecture, Yunnan Province, China, 2022–2024.

The process of contact tracing	First round	Second round	Third round	Total
Number of index HIV cases	1,925	54	2	1,981
Number and proportion (%) of index HIV cases traced at least one sexual contact tested positive*	305 (15.8)	9 (16.7)	0 (0)	314 (15.9)
Number of sexual contacts reported by index cases	2,097	69	5	2,171
Number and proportion (%) of sexual contacts received HIV testing†	1,474 (70.3)	32 (46.4)	3 (60.0)	1,509 (69.5)
Number and proportion (%) of sexual contacts tested HIV positive§	308 (20.9)	9 (28.1)	0 (0)	317 (21.0)

Abbreviation: HIV=human immunodeficiency virus.
* Contact tracing efficacy: proportion of index cases that led to identification of at least one HIV-positive contact, calculated as the number of index cases with HIV-positive contacts divided by total index cases.
† HIV testing uptake: proportion of contacts who received HIV testing, calculated as the number of contacts tested divided by total contacts.
§ HIV positivity rate: proportion of tested contacts who were HIV-positive, calculated as the number of contacts testing positive divided by total contacts tested.

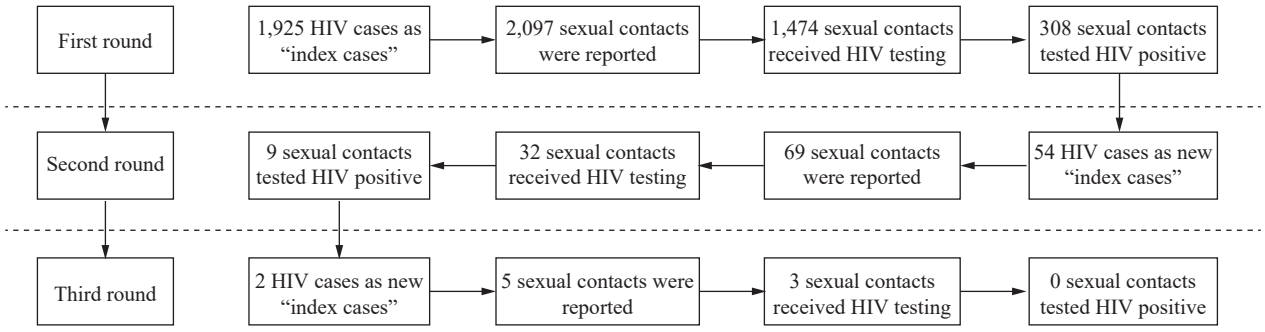
SUPPLEMENTARY TABLE S2. Sociodemographic and behavioral characteristics of index HIV cases and sexual contacts in Honghe Prefecture, Yunnan Province, China, 2022–2024.

Characteristic	Index *N*=1,981		Contacts *N*=2,171		χ^2/F	*P*
	n	%	*n*	%		
Sex					185.827	<0.001
Male	1,350	68.2	844	38.9		
Female	631	31.8	1,327	61.1		
Age*					919.34	<0.001
Mean (SD)	47.1	12.9	40.4	12.0		
<18 years	0	0.0	19	0.8		
18–35 years	378	19.1	809	37.3		
36–55 years	1,062	53.6	1,089	50.2		
≥56 years	541	27.3	254	11.7		
Ethnicity					83.544	<0.001
Han	728	36.8	1,030	47.4		
Ethnic minorities	1,253	63.3	1,141	52.6		
Education					35.679	<0.001
≤Primary school	1,248	63.0	1,432	66.0		
Junior high school	512	25.8	592	27.3		
≥Senior high school	221	11.2	147	6.7		
Marital status					42.486	<0.001
Never married	506	25.5	651	30.0		
Currently married	863	43.6	775	35.7		
Divorced or widowed	612	30.9	745	34.3		
Occupation					3.638	0.057
Unemployed	320	16.2	309	14.2		
Employed	1,661	83.8	1,862	85.8		
Type of HIV testing						
Passive testing	1,684	85.0				
Active testing	297	15.0				

Continued

Characteristic	Index N=1,981		Contacts N=2,171		χ^2/F	P
	n	%	n	%		
CD4 counts at baseline (cells/microliter)						
≤200	695	35.1				
201–350	587	29.6				
351–500	359	18.1				
≥501	301	15.2				
Unknown	39	2.0				
Type of sexual relationship with index case						
Spouse or long-term sexual partnership			375	17.3		
Commercial sexual partnership			681	31.4		
Non-marital and non-commercial sexual partnership			1,115	51.3		
Duration of sexual relationship with index case						
≤1 year			1,560	71.9		
1–3 years			200	9.2		
>3 years			411	18.9		
Frequency of sexual behavior with index case in the past 6 months						
<once a week			554	25.5		
1–2 times a week			1,379	63.5		
≥3 times a week			238	11.0		
Frequency of condom use with index case in the past 6 months						
Never			1,428	65.8		
Inconsistently			506	23.3		
Consistently			237	10.9		

Abbreviation: HIV=human immunodeficiency virus; SD=standard deviation.
* Chi-square analysis was not feasible due to zero-frequency cells. Age disparity between groups was alternatively analyzed using survey regression procedures ("proc surveyreg").



SUPPLEMENTARY FIGURE S1. Process flowchart of HIV contact tracing and case identification.
Abbreviation: HIV=human immunodeficiency virus