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Preplanned Studies

Impact of HIV Pretreatment Drug Resistance on Virological Failure After One-Year Antiretroviral Therapy — China, 2018–2019

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Summary

What is already known about this topic?

While antiretroviral therapy (ART) has been rapidly scaled-up among the population living with human immunodeficiency virus or acquired immune deficiency syndrome (HIV/AIDS) patients since 2016, pretreatment drug resistance (PDR) has also increased.

What is added by this report?

PDR has an impact on ART outcomes. After one year of ART, the risk of virological failure in individuals with PDR was found to be 2.3 times higher than that of individuals without PDR. Moreover, patients with PDR to non-nucleoside reverse transcriptase inhibitors (NNRTIs) had an even higher risk of virological failure, with an odds ratio of 2.8 as compared with those without PDR.

What are the implications for public health practice?

PDR is associated with an increased risk of virological failure. It is recommended to regularly implement PDR monitoring in order to provide information to optimize ART regimens and to prevent HIV drug resistance.

The National Free Antiretroviral Therapy Program has been scaled-up since 2003 in China, resulting in a remarkable reduction of human immunodeficiency virus or acquired immune deficiency syndrome (HIV/AIDS)-related morbidity and mortality (*1*). With wide coverage of antiretroviral therapy (ART), a certain degree of HIV drug resistance was anticipated. The prevalence of pretreatment drug resistance (PDR) ranges from 3.5% to 25.8% in various countries (*2*). PDR surveillance was conducted among individuals prior to initiating ART in 31 provincial-level administrative divisions (PLADs) of China in 2018 (2018 PDR survey). The prevalence of PDR was at a moderate level and was relatively high in regions with higher HIV/AIDS burdens. This study analyzed the follow-up data after one year of ART among individuals with and without PDR in order to investigate the effect of PDR and other risk factors on the virological response of ART in China. The main finding was that the overall virological failure (viral load ≥1,000 copies/mL) in participants in this study was 10.1% after one year of ART, and individuals with PDR of non-nucleoside reverse transcriptase inhibitors (NNRTIs) had an even higher risk of virological failure. This study therefore provided further information and valuable references for optimizing regimens.

According to the 2014 World Health Organization (WHO) surveillance guidelines for HIV PDR and the pilot work using HIV resistance surveys in some regions of China in 2017 (*3*–*4*) and based on a cross-sectional survey of PDR in 31 PLADs in 2018, a one-year prospective follow-up survey of ART was conducted in 2019. In the 2018 PDR survey (source population of 5,151 people), 352 individuals with PDR were detected (cases), then those without PDR (controls) were selected according to a 1∶2 individual matching scheme at the same time. All individuals had to be aged 18 years or older. Individuals in case and control groups were followed up with after one-year of ART. While among individuals with PDR, 35 patients never started ART, 42 patients did not start ART immediately and therefore did not complete one year of ART by the follow-up appointment, 104 patients did not have a viral load test at the follow-up appointment, and 23 patients were unable to receive follow-up at all. In the end, this study included 464 participants, of which 148 individuals had PDR. Institutional review board approval was granted by the National Center for AIDS/STD Control and Prevention and the Chinese Center for Disease Control and Prevention. Informed consent was obtained from all participants involved in the study. Plasma samples were also collected, and the HIV viral load was measured. Virological failure was defined as HIV RNA viral load ≥1,000 copies/mL one year after treatment initiation. HIV genotype drug resistance tests were performed on plasma samples from all subjects before ART, and from individuals with virological failure after one-year of ART. The outcome variable was virological failure (viral load ≥1,000 copies/mL). All the demographic and clinical characteristics were included in univariate logistic regression analyses. Variables with $P<0.1$ were entered multivariable logistic regression analyses. In addition, PDR was stratified by all antiretroviral drugs (ARVs), ARV classes, and specific ARVs. The SAS (version 9.4, SAS Institute, Cary, NC, USA) was used to conduct all analyses. Two-sided $P<0.05$ was considered statistically significant.

A total of 464 participants (148 and 316 individuals with and without PDR, respectively) were included in this study (Table 1), of which 47.8% and 45.7% of the participants were infected through heterosexual and homosexual contact, respectively. The proportions of participants with CRF01_AE, CRF07_BC, and CRF08_BC HIV-1 strains were 33.8%, 36.0%, and 12.5%, respectively. The initial ART regimen for 81.3% of participants was tenofovir (TDF) and lamivudine (3TC) in combination with efavirenz (EFV) or nevirapine (NVP). Individuals with and without PDR were comparable in age, gender, education level, HIV infection route, initial ART regimen, and CD4 cell counts before ART, and there was no statistically significant difference.

Based on the HIV genotype drug resistance analysis, 148 individuals were shown to have PDR. Among them, 8.8% (13/148) of the participants were resistant to nucleoside reverse-transcriptase inhibitors (NRTIs), which carried M184VI (2.7%, 4/148), T215ANS (2.7%, 4/148), and other drug resistance mutations (Figure 1A). 59.5% (88/148) of the participants were resistant to NNRTIs. For NNRTIs, E138AGK (33.8%, 50/148) was the most common PDR mutation, and other frequent PDR mutations included V179DE (23.0%, 34/148), K103NQR (14.2%, 21/148), and V106MI (6.1%, 9/148). E138AGK caused low-level reductions in susceptibility to rilpivirine (RPV), the combination of V179DE and E138G synergistically acted to reduce EFV, NVP, and RPV susceptibility at a low level, and the combination of V179DE and other NNRTIs drug resistance mutations caused intermediate- or high-level reductions in susceptibility to EFV and NVP. There were 12.8% and 15.5% of participants that showed high-level PDR to EFV and NVP, respectively (Figure 1B). 35.8% (53/148) of the participants were resistant to protease inhibitors (PIs), and the main mutations were M46LI (14.2%, 21/148) and Q58E (17.6%, 26/148). After one-year of ART, 33 (7.1%, 33/464) patients had drug-resistant mutations. Among them, 21 patients had PDR before ART and 12 did not. 6.5% (30/464) of patients were mainly resistant to NNRTIs after ART.

Next, 47 (10.1%, 47/464) people experienced virological failure one year after receiving an initial ART. Among them, 23 (15.5%, 23/148) were individuals with PDR, and 24 (7.6%, 24/316) without PDR. Risk factors of virological failure after one year of ART were assessed using logistic regression. The univariate logistic regression analysis showed that ethnicity, route of HIV infection, subtype, initial ART regimen, missed doses in the past month, and PDR were possible predictors of virological failure. After adjusting for demographic and clinical characteristics: age, gender, ethnicity, education, routes of HIV infection, subtype, and CD4 cell count before initial ART regimen, initial ART regimen, and missed doses in the past month, multivariate regression analysis stratified by the study was used to estimate the risk of virological failure. This study found that the risk of virological failure after one year of ART for individuals with PDR was 2.3 [95% confidence interval (CI): 1.2–4.6, P=0.01] times that of those without PDR (model 1, Table 2). Compared with populations without PDR, individuals who were resistant to NNRTIs before initial ART had a 2.8-fold (95% CI: 1.3–6.2, P=0.01) increase in the risk of virological failure (model 2, Table 2). Moreover, the results show that compared with individuals without PDR, the risk of virological failure among individuals resistant to EFV/NVP [adjusted OR (aOR)=3.2, 95% CI: 1.3–8.2] is statistically significantly higher (model 3, Table 2).

DISCUSSION

A prospective survey in 31 PLADs of China was conducted to investigate the impact of HIV PDR on virological failure after one-year of ART. A total of 464 participants (148 participants with PDR and 316 participants without PDR) were included in the analysis. Compared with individuals without PDR, the risk of virological failure was higher in individuals with PDR.

After one year of ART, the overall virological failure

TABLE 1. Demographic and clinical characteristics of participants with and without PDR.

Variable	No. of participants, n (%)	No. of individuals with PDR, n (%)	No. of individuals without PDR, n (%)
Total	464 (100.0)	148 (100.0)	316 (100.0)
Age (years)			
18–29	108 (23.3)	23 (15.5)	85 (26.9)
30–39	119 (25.6)	43 (29.1)	76 (24.1)
40–49	96 (20.7)	34 (23.0)	62 (19.6)
≥50	141 (30.4)	48 (32.4)	93 (29.4)
Gender			
Male	385 (83.0)	125 (84.5)	260 (82.3)
Female	79 (17.0)	23 (15.5)	56 (17.7)
Ethnicity			
Han	401 (86.4)	123 (83.1)	278 (88.0)
Other	63 (13.6)	25 (16.9)	38 (12.0)
Education			
Illiterate	18 (3.9)	5 (3.4)	13 (4.1)
Primary and junior middle school	226 (48.7)	77 (52.0)	149 (47.2)
Senior middle school and higher	206 (44.4)	61 (41.2)	145 (45.9)
Missing	14 (3.0)	5 (3.4)	9 (2.8)
Route of HIV infection			
Heterosexual	222 (47.8)	72 (48.6)	150 (47.5)
Homosexual	212 (45.7)	65 (43.9)	147 (46.5)
Injection drug use	11 (2.4)	3 (2.0)	8 (2.5)
Other	17 (3.7)	7 (4.7)	10 (3.2)
Missing	2 (0.4)	1 (0.7)	1 (0.3)
Subtype			
CRF01_AE	157 (33.8)	48 (32.4)	109 (34.5)
CRF07_BC	167 (36.0)	53 (35.8)	114 (36.1)
CRF08_BC	58 (12.5)	20 (13.5)	38 (12.0)
CRF55_01B	19 (4.1)	13 (8.8)	6 (1.9)
B	28 (6.0)	4 (2.7)	24 (7.6)
Other	35 (7.5)	10 (6.8)	25 (7.9)
Initial ART regimen			
AZT+3TC+EFV/NVP	57 (12.3)	20 (13.5)	37 (11.7)
AZT+3TC+LPV/r	9 (1.9)	2 (1.4)	7 (2.2)
TDF+3TC+EFV/NVP	377 (81.3)	120 (81.1)	257 (81.3)
TDF+3TC+LPV/r	16 (3.4)	6 (4.0)	10 (3.2)
Other	5 (1.1)	0 (0.0)	5 (1.6)
CD4 cell count before initial ART regimen (cells/mm^3)			
0–199	168 (36.2)	50 (33.8)	118 (37.3)
200–349	147 (31.7)	48 (32.4)	99 (31.3)
350–499	92 (19.8)	28 (18.9)	64 (20.3)
≥500	54 (11.6)	21 (14.2)	33 (10.4)
Missing	3 (0.6)	1 (0.7)	2 (0.6)
Missed doses in the past month			
No	283 (61.0)	87 (58.8)	196 (62.0)
Yes	36 (7.8)	12 (8.1)	24 (7.6)
Unknown	145 (31.2)	49 (33.1)	96 (30.4)

Abbreviations: PDR=pretreatment drug resistance; HIV=human immunodeficiency virus; CRF=circulating recombinant form; ART=antiretroviral therapy; AZT=Zidovudine; 3TC=Lamivudine; EFV=Efavirenz; NVP=Nevirapine; LPV/r=Lopinavir/r; TDF=Tenofovir.

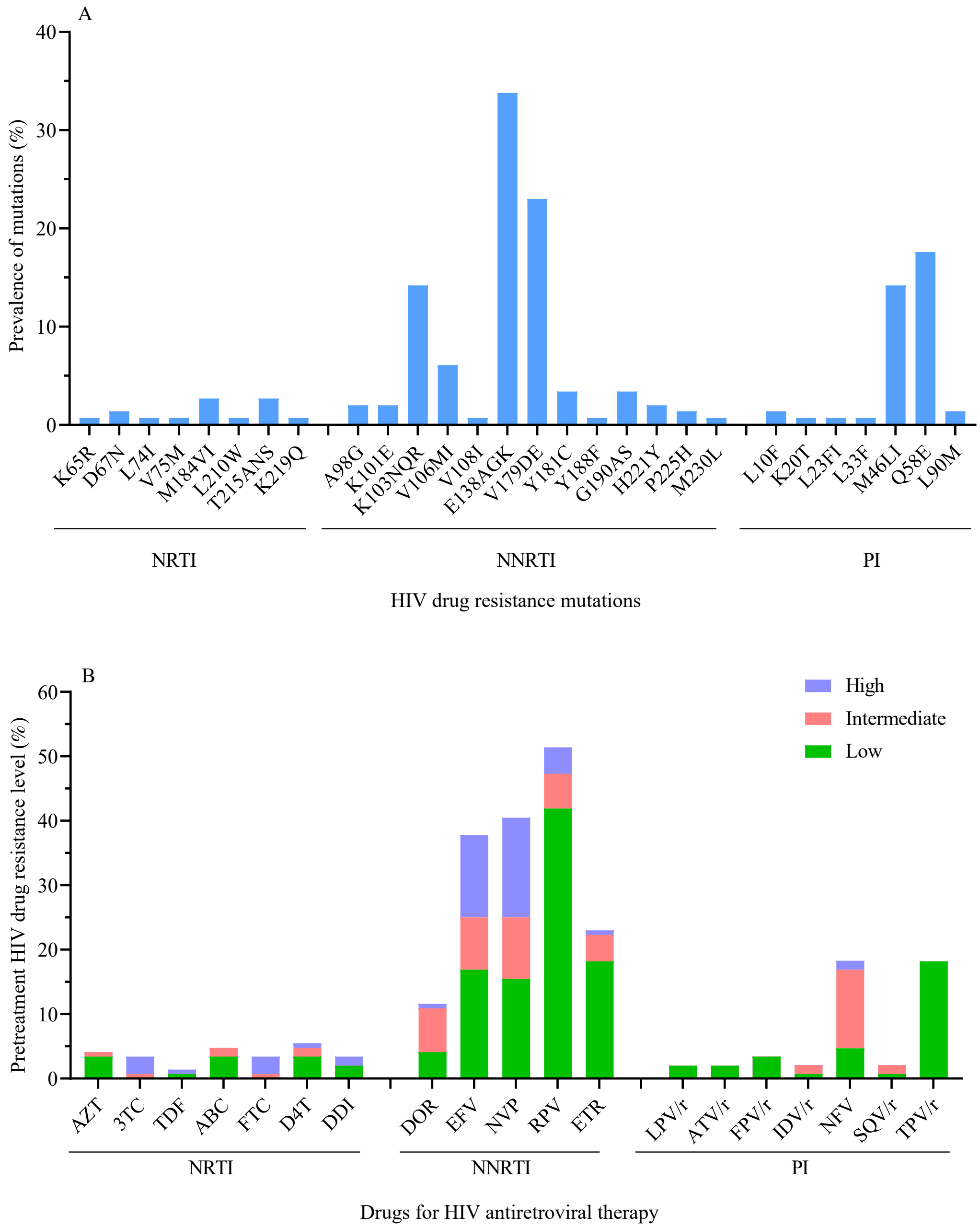

FIGURE 1. HIV drug resistance mutations and antiretroviral drugs among 148 individuals with PDR. (A) Analysis of HIV drug resistance mutations among 148 individuals with PDR; (B) Analysis of HIV drug resistance levels among 148 individuals with PDR.

Notes: The estimated level of HIV resistance to a drug was determined by the Stanford HIVdb program from Sanger sequences. Once the total score was calculated, the estimated level of resistance was calculated as follows: low-level resistance (total score 15 to 29), intermediate resistance (total score 30 to 59), high-level resistance (total score ≥60).

Abbreviations: PDR=pretreatment drug resistance; HIV=human immunodeficiency virus; NRTI=nucleoside reverse-transcriptase inhibitor; AZT=Zidovudine; 3TC=Lamivudine; TDF=Tenofovir; ABC=Abacavir; FTC=Emtricitabine; D4T=Stavudine; DDI=Didanosine; NNRTI=non-nucleoside reverse-transcriptase inhibitor; DOR=Doravirine; EFV=Efavirenz; NVP=Nevirapine; RPV=Rilpivirine; ETR=Etravirine; PI=protease inhibitor; LPV/r=Lopinavir/r; ATV/r=Atazanavir/r; FPV/r=Fosamprenavir/r; IDV/r=Indinavir/r; NFV=Nelfinavir; SQV/r=Saquinavir/r; TPV/r=Tipranavir/r.

(viral load ≥1,000 copies/mL) in the participants in this study was 10.1%. Among them, 15.5% and 7.6% of individuals with and without PDR had virological failure, respectively. Virological failure was defined as a viral load ≥400 copies/mL after one-year of ART. The results showed that the overall virological failure was

TABLE 2. Factors associated with virological failure (VL ≥1,000 copies/mL) in HIV/AIDS populations one year after initial antiretroviral therapy.

Model	Factors	Total	No. of VL ≥1,000 copies/mL (%)	OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
	Total	464	47 (10.1)	−	−	−	−
Model 1	PDR						
	Without	316	24 (7.6)	1.0		1.0	
	With	148	23 (15.5)	2.2 (1.2–4.1)	0.01	2.3 (1.2–4.6)	0.01
Model 2	For drug categories						
	Without resistance	316	24 (7.6)	1.0	−	1.0	−
	Resistance to NRTIs	10*	1 (10.0)	1.4 (0.2–11.1)	0.78	1.6 (0.2–15.2)	0.66
	Resistance to NNRTIs	88	16 (18.2)	2.7 (1.4–5.4)	<0.01	2.8 (1.3–6.2)	0.01
	Resistance to PIs	50*	6 (12.0)	1.7 (0.6–4.3)	0.30	1.7 (0.6–5.0)	0.30
Model 3	For antiretroviral drugs						
	Without resistance	316	24 (7.6)	1.0	−	1.0	−
	Resistance to EFV/NVP	60	10 (16.7)	2.4 (1.1–5.4)	0.03	3.2 (1.3–8.2)	0.01
	Resistance to other drugs	88	13 (14.8)	2.1 (1.0–4.3)	0.04	1.9 (0.8–4.3)	0.12

Note: "−" means not applicable.

Abbreviations: VL=viral load; HIV=human immunodeficiency virus; AIDS=acquired immune deficiency syndrome; OR=odds ratio; CI=confidence interval; PDR=pretreatment drug resistance; NNRTI=non-nucleoside reverse-transcriptase inhibitor; NRTI=nucleoside reverse-transcriptase inhibitor; PI=protease inhibitor; EFV=Efavirenz; NVP=Nevirapine.

* This number refers to individuals who were only resistant to PIs or NRTIs, excluding the three individuals with multi-drug resistance.

12.1% (56/464). The proportion of virological failure in individuals with and without PDR were 16.2% (24/148) and 10.1% (32/316), respectively. In addition, we found that 18.2% of individuals with NNRTIs pretreatment resistance experienced virological failure after one year of initial ART. A cross-sectional study of HIV PDR in parts of China showed that the overall prevalence of PDR was 6.8%, while the prevalence of NNRTIs PDR was 4.6% (*3*). This was consistent with the present study in which the majority of participants with PDR were resistant to NNRTIs. Previous studies and meta-analysis (*5*–*6*) also found that the prevalence of NNRTI-related PDR was higher than that of NRTIs. Compared to individuals without PDR, those with PDR that initiated NNRTIs had an increased risk of virological failure.

The findings in this study were in line with the cohort study of Hamers et al. (*7*), which found an odds ratio of approximately two for virological failure in individuals with PDR. Furthermore, we found that participants who were resistant to NNRTIs before ART were more likely to have an increased risk of virological failure than those without PDR. In addition, resistance to EFV/NVP in prescribed drugs, had an odds ratio of 3.2 for virological failure in patients with PDR. Furthermore, we observed that the resistance prevalence of RPV was as high as 51.4%, which was caused by the mutation E138AGK. Even if RPV was not in first line or second line ART regimens in China, it still needed to be monitored and used with caution. Therefore, when people living with HIV or AIDS initially receive ART, the possibility of baseline drug resistance must be considered.

The study was subject to some limitations. First, the number of patients with PDR was limited. This is indicative of the relatively low level of PDR in China. In the 2018 PDR survey, PDR to all ARVs was only 6.8% and the level of PDR to EFV/NVP was even lower to 2.7%. Secondly, only 42% of the patients with PDR in 2018 survey were included in this study. However, the patients with PDR that were included had the same profile of drug resistance mutations as those not included and had comparable demographic characteristics (data not shown). Therefore, the study's population could largely represent the whole PDR group in 2018 survey. Moreover, the findings that PDR to EFV/NVP could compromise the efficacy of ART were similar to observations in other countries. Thus, while the results can be extrapolated, caution should be taken to understand the datasets.

In conclusion, PDR significantly reduced the efficacy of ART, especially as resistance to NNRTIs was prone to lead to virological failure. Therefore, HIV genotype drug resistance surveillance should be strengthened before initial ART in order to guide the selection of the initial regimen and avoid virological failure in individuals with PDR. There should also be routine monitoring of HIV drug resistance at the population level to ensure the continued effectiveness of ART in order to achieve the global goal of eliminating AIDS as a public health threat by 2030.

Conflicts of interest: No conflicts of interest.

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REFERENCES

1. Cao W, Hsieh E, Li TS. Optimizing treatment for adults with HIV/AIDS in China: successes over two decades and remaining challenges. Curr HIV/AIDS Rep 2020;17(1):26 – 34. http://dx.doi.org/10.1007/s11904-019-00478-x.
2. Bertagnolio S, Hermans L, Jordan MR, Avila-Rios S, Iwuji C, Derache A, et al. Clinical impact of pretreatment human immunodeficiency virus drug resistance in people initiating nonnucleoside reverse transcriptase inhibitor-containing antiretroviral therapy: a systematic review and meta-analysis. J Infect Dis 2021;224(3):377 – 88. http://dx.doi.org/10.1093/infdis/jiaa683.
3. Kang RH, Liang SJ, Ma YL, Liang S, Xiao L, Zhang XH, et al. Pretreatment HIV drug resistance in adults initiating antiretroviral therapy in China, 2017. Infect Dis Poverty 2020;9(1):54. http://dx.doi.org/10.1186/s40249-020-00668-5.
4. World Health Organization. Surveillance of HIV drug resistance in adults initiating antiretroviral therapy (pre-treatment HIV drug resistance). 2014. http://apps.who.int/iris/bitstream/handle/10665/112802/9789241507196_eng.pdf?sequence=1. [2021-7-22].
5. Gupta RK, Gregson J, Parkin N, Haile-Selassie H, Tanuri A, Andrade FL, et al. HIV-1 drug resistance before initiation or re-initiation of first-line antiretroviral therapy in low-income and middle-income countries: a systematic review and meta-regression analysis. Lancet Infect Dis 2018;18(3):346 – 55. http://dx.doi.org/10.1016/S1473-3099(17)30702-8.
6. Ávila-Rios S, García-Morales C, Matías-Florentino M, Romero-Mora KA, Tapia-Trejo D, Quiroz-Morales VS, et al. Pretreatment HIV-drug resistance in Mexico and its impact on the effectiveness of first-line antiretroviral therapy: a nationally representative 2015 WHO survey. Lancet HIV 2016;3(12):e579 – 91. http://dx.doi.org/10.1016/S2352-3018(16)30119-9.
7. Hamers RL, Schuurman R, Sigaloff KC, Wallis CL, Kityo C, Siwale M, et al. Effect of pretreatment HIV-1 drug resistance on immunological, virological, and drug-resistance outcomes of first-line antiretroviral treatment in sub-Saharan Africa: a multicentre cohort study. Lancet Infect Dis 2012;12(4):307 – 17. http://dx.doi.org/10.1016/S1473-3099(11)70255-9.

Preplanned Studies

Oral Sexual Behavior Among HIV-Infected Men Who Have Sex with Men — China, February 2021

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Summary

What is already known about this topic?

Unprotected oral sex carries a risk of the transmission of sexually transmitted infections (STIs), especially if the individual has poor oral health.

What is added by this report?

Most human immunodeficiency virus (HIV) infected men who have sex with men (MSM) had never used a condom when giving oral sex (89.30%, 718/804) or receiving oral sex (90.32%, 709/785). Among MSM with detectable viral loads who had ever received oral sex without a condom, 40.00% reported ejaculation in their partner’s mouth.

What are the implications for public health practice?

Unprotected oral sex is very common among HIV-infected MSM in China. The public health sectors in China should recommend condom use during oral sex among HIV-infected MSM, especially when in-mouth ejaculation is involved.

Oral sex is one of the most common sexual activities. Although evidence supports that unprotected oral sex carries a risk of the transmission of sexually transmitted infections (STIs), especially if the individual has a poor oral health, the risk of human immunodeficiency virus (HIV) transmission through oral sex is much lower than that through anal sex (*1*). Many people, including people living with HIV (PLWH), may think that oral sex carries little or no risk for the transmission of HIV and other STIs. After knowing their HIV status, they may increase the frequency of oral sex and decrease that of anal sex in order to minimize HIV transmission to others. As a result, PLWH may be more likely to have regular oral sex than the uninfected population (*2*). Unprotected oral sex is common among men who have sex with men (MSM) (*3*). A cross-sectional study from China showed that only 6.87% of 5,181 MSM reported condom use in their last oral sex (*4*). Sarah et al. found that a higher proportion of HIV-infected MSM (75.00%) reported having oral sex than uninfected MSM (59.00%) (*2*). Another study from Thailand showed that 85.00% of HIV-infected MSM had reported unprotected oral sex, significantly higher than the proportion of unprotected anal sex (32.00%) (*5*). The purpose of the current study was to investigate oral sexual behavior and factors associated with the use of condoms in oral sex among HIV-infected MSM in China. Most participants in this study never used a condom when giving oral sex (89.30%, 718/804) or receiving oral sex (90.32%, 709/785). Among the 85 participants with a detectable viral load who received oral sex without a condom, 40.00% reported that they had ever ejaculated in their partner’s mouth. It is necessary for clinicians and public health practitioners to develop targeted education and interventions for HIV-infected MSM to minimize the risk from unprotected oral sex.

We conducted a nationwide cross-sectional online survey in February 2021 in China. Convenience sampling was applied in this study. A total of 873 eligible participants were recruited through Li Hui Shi Kong, a WeChat official account with more than 76,000 HIV-infected followers. Details of the description of Li Hui Shi Kong are available in a previously published literature (*6*). Eligibility criteria included self-identified MSM, having oral sex with at least one man in the past six months, and having a known diagnosis of HIV. The following measures were taken to ensure the quality of the questionnaire results: 1) each mobile phone or computer could only be used once; 2) a pre-investigation of 12 HIV-infected MSM was conducted to modify questionnaires before the formal launch of the survey; 3) invalid questionnaires were identified by the logic checks built into the back-end system; 4) quality-controlled questions were designed to exclude participants filling in wrong answers (e.g., “How many seasons are there?”); 5) participants who finished questionnaires within a short answer time (less than 5 minutes), and those who chose the same option in all choice questions were also excluded. Every eligible participant received a reimbursement of 4.6 USD to 15.4 USD as an incentive through an online random lottery. Oral sexual behaviors included the following questions: in the past six months, 1) type of oral sex (given, received, or both); 2) frequency of oral sex; 3) number of oral sex male partners; 4) condom use when giving or receiving oral sex; 5) ever ejaculated in partners' mouth; 6) mouthwash use before or after performing oral sex. To ensure that all participants were using the same definition of oral sex, a short statement was given on the survey, defining giving oral sex as "putting your mouth on your partner's penis (Oral-Penis)" and receiving oral sex as "putting your penis in your partner's mouth (Penis-Oral)." Unprotected oral sex in this study was defined as the absence of condom use during oral sex.

The chi-squared test was used to compare the oral sexual behavior between different viral loads of HIV in the last six months of HIV-infected MSM. Univariate logistic regressions were performed to identify factors potentially associated with unprotected oral sex. Odds ratios (OR) and 95% confidence intervals (CI) were calculated in univariate analysis. Variables with $P<0.2$ in univariate analysis were included in multivariable modeling, which was performed using multiple logistic regression. All analyses were conducted using IBM SPSS (version 20.0, SPSS, Inc. Chicago, USA), and $P<0.05$ was considered significant.

The proportion of transgender women was 9.85% (86/873). The age of participants ranged from 16 to 63 years (median=29, interquartile range: 25–34). In all participants, 59.22% (517/873) used social apps to find sexual partners, and 37.46% (327/873) had regular male partners (Table 1). In the past 6 months, the proportions of participants who reported ever giving oral sex and receiving oral sex were 92.10% (804/873) and 89.92% (785/873). Most participants never used a condom when giving oral sex (89.30%, 718/804) or receiving oral sex (90.32%, 709/785). Overall, 35.26% (250/709) of the participants reported ejaculation in their partner's mouth when receiving oral sex without a condom, and 53.15% (464/873) used mouthwash before or after performing oral sex. Among the 126 participants with a detectable viral load in the past 6 months, 67.46% (85/126) reported receiving oral sex without a condom.

HIV-infected MSM with an undetectable viral load were more likely to receive oral sex in the past 6 months ($P<0.001$), and those with a detectable viral load were on a more frequent basis ($P=0.005$) (Table 2). A higher proportion of HIV-infected MSM with detectable viral load reported condom use when giving oral sex (19.13% *vs.* 7.96%, $P<0.001$) and receiving oral sex (15.84% *vs.* 8.17%, $P=0.042$) in the past 6 months compared to those with undetectable viral load. Among the 85 participants with detectable viral load who had ever received oral sex without a condom, 40.00% (34/85) reported ejaculation in their partner's mouth.

In multivariable logistic regression analysis, HIV-infected MSM who were circumcised [adjusted odds ratio (aOR)=0.6, 95% CI: 0.4–0.8] were less likely to have unprotected oral sex. HIV-infected MSM who found sexual partners via social apps (aOR=2.5, 95% CI: 1.7–3.7), used alcohol before or during sexual

TABLE 1. Basic characteristics of HIV-infected men who have sex with men in China who ever had oral sex in the past six months.

Characteristics	n (%)
Number of participants	873 (100.00)
Gender Identity	
Cisgender male	787 (90.15)
Transgender women	86 (9.85)
Age (years)	
≤25	276 (31.62)
26–44	570 (65.29)
≥45	27 (3.09)
Education	
High school or below	181 (20.73)
Bachelor or college	611 (69.99)
Master or doctor	81 (9.28)

TABLE 1. (Continued)

Characteristics	n (%)
Chinese geographical division*	
North China	155 (17.75)
Northeast China	66 (7.56)
East China	256 (29.32)
Central China	114 (13.06)
South China	124 (14.20)
Southwest China	109 (12.49)
Northwest China	49 (5.61)
Marital status	
Unmarried	757 (86.71)
Married	75 (8.59)
Other	41 (4.70)
Employment status	
Full-time employment	523 (61.89)
Freelancer	167 (19.76)
Student	86 (10.18)
Unemployed	69 (8.17)
Salary (CNY)	
0–1,999	132 (15.12)
2,000–4,999	331 (37.92)
5,000–9,999	302 (34.59)
≥10,000	108 (12.37)
Sexual orientation	
Heterosexual	10 (1.15)
Homosexual	691 (79.15)
Other or not sure	172 (19.70)
Way to find sex partners	
Regular partner	327 (37.46)
Social app	517 (59.22)
Bar/party/bathhouse	40 (4.58)
Workmates	19 (2.18)
Friend recommendation	31 (3.55)
Gym	20 (2.29)
Gay community	20 (2.29)
HIV status of regular male partner	
Positive	116 (35.47)
Negative	153 (46.79)
Unknown	58 (17.74)
Time since HIV diagnosis (months)	
<12	162 (18.56)
13–35	300 (34.36)
≥36	411 (47.08)
Viral load of HIV in the last year	
Detectable (at least once)	126 (14.43)
Undetectable	613 (70.22)
Not sure	134 (15.35)

TABLE 1. (Continued)

Characteristics	n (%)
Taking HIV medications	
Yes	801 (91.75)
No	72 (8.25)
Recreational drug use before or during sexual activities	
Yes	525 (60.14)
No	348 (39.86)
Alcohol use before or during sexual activities	
Yes	316 (36.20)
No	557 (63.80)
Circumcised	
Yes	226 (25.89)
No	647 (74.11)
Type of oral sex	
Ever giving oral sex†	804 (92.10)
Receiving oral sex§	785 (89.92)
Frequency of oral sex	
≥10 times per month	55 (6.30)
4–9 times per month	106 (12.14)
1–3 times per month	296 (33.91)
<1 time per month	416 (47.65)
Number of oral sex male partners	
≥6 per month	27 (3.09)
2–5 per month	177 (20.27)
1 per month	259 (29.67)
<1 per month	410 (46.96)
Condom use when giving oral sex	
Sometime/often	86 (10.70)
Never	718 (89.30)
Condom use when receiving oral sex	
Sometime/often	76 (9.68)
Never	709 (90.32)
Ever ejaculated in partners' mouth when receiving oral sex without a condom	
Yes	250 (35.26)
No	459 (64.74)
Mouthwash before/after oral sex	
Yes	464 (53.15)
No	409 (46.85)

Note: Numbers may vary due to missing data.
Abbreviations: CNY=Chinese Yuan; PLAD=provincial-level administrative division; HIV=human immunodeficiency virus.
* Chinese Geographical Divisions by PLADs: North China (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia); Northeast China (Heilongjiang, Jilin, Liaoning); East China (Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Shandong, Fujian, Taiwan); Central China (Henan, Hubei, Hunan); South China (Guangdong, Guangxi, Hainan, Hong Kong, Macao); Southwest China [Chongqing, Sichuan, Guizhou, Yunnan, Xizang (Tibet)]; Northwest China (Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang).
† Giving oral sex: putting your mouth on your partner's penis (Oral-Penis).
§ Receiving oral sex: putting your penis in your partner's mouth (Penis-Oral).

TABLE 2. Characteristics of oral sex in MSM with different HIV viral loads in China.

Variables	Detectable n (%)	Undetectable n (%)	Not sure n (%)	*P* value
Ever giving oral sex*				0.924
Yes	115 (91.27)	565 (92.17)	124 (92.54)	
No	11 (8.73)	48 (7.83)	10 (7.46)	
Ever receiving oral sex§				<0.001
Yes	101 (80.16)	563 (91.84)	121 (90.30)	
No	25 (19.84)	50 (8.16)	13 (9.70)	
Frequency of oral sex				0.005
≥10 times per month	16 (12.70)	27 (4.40)	12 (8.96)	
4–9 times per month	20 (15.87)	69 (11.26)	17 (12.68)	
1–3 times per month	40 (31.75)	208 (33.93)	48 (35.82)	
<1 time per month	50 (39.68)	309 (50.41)	57 (42.54)	
Number of oral sex male partners				0.001
≥6 per month	5 (3.97)	14 (2.28)	8 (5.97)	
2–5 per month	32 (25.40)	107 (17.46)	38 (28.36)	
1 per month	43 (34.13)	187 (30.51)	29 (21.64)	
<1 per month	46 (36.50)	305 (49.75)	59 (44.03)	
Condom use when giving oral sex				<0.001
Sometime/often	22 (19.13)	45 (7.96)	19 (15.32)	
Never	93 (80.87)	520 (92.04)	105 (84.68)	
Condom use when receiving oral sex				0.042
Sometime/often	16 (15.84)	46 (8.17)	14 (11.57)	
Never	85 (84.16)	517 (91.83)	107 (88.43)	
Ever ejaculated in partners' mouth when receiving oral sex without a condom				0.258
Yes	34 (40.00)	173 (33.46)	43 (40.19)	
No	51 (60.00)	344 (66.54)	64 (59.81)	
Mouthwash before/after oral sex				0.050
Yes	79 (62.70)	320 (52.20)	65 (48.51)	
No	47 (37.30)	293 (47.80)	69 (51.49)	
Total	126	613	134	

Detectable: HIV viral load can be detected at least once in the past six months.
Abbreviations: MSM=men who have sex with men; HIV=human immunodeficiency virus.
*Giving oral sex: putting your mouth on your partner's penis (Oral-Penis).
§ Receiving oral sex: putting your penis in your partner's mouth (Penis-Oral).

activities (aOR=1.7, 95% CI: 1.2–2.4), and with an undetectable viral load in the past 6 months (aOR=2.1, 95% CI: 1.3–3.3) were more likely to engage in oral sex without a condom. (Table 3)

DISCUSSION

The study found a high proportion of HIV-infected MSM engaged in oral sex without a condom. Since the risk of HIV transmission through oral sex is much lower than that during anal sex, people might mistakenly believe that unprotected oral sex is not a risky sexual behavior. Our findings showed that among the 85 participants with detectable viral loads who had ever received oral sex without a condom, 40.00% had ever ejaculated in the partner's mouth. Being exposed to semen and having sores in the mouth or on the genital may increase a person's chance of getting HIV or other STIs during oral sex, even when the infected partner has an undetectable viral load (*7*). The results of this study indicated that it was possible for HIV-infected MSM to transmit HIV to their sexual

TABLE 3. Factors associated with unprotected oral sex among HIV-infected MSM in China.

Characteristics	Unadjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Gender Identity				
Cisgender male	Ref			
Transgender women	0.7 (0.4–1.1)	0.107	0.8 (0.5–1.3)	0.371
Age (year)				
≤25	Ref			
26–44	1.2 (0.9–1.7)	0.270		
≥45	1.6 (0.6–4.4)	0.353		
Education				
High school or below	Ref			
Bachelor or college	0.8 (0.6–1.3)	0.407		
Master or doctor	1.4 (0.7–2.7)	0.326		
Marital status				
Unmarried	Ref			
Married	0.8 (0.5–1.3)	0.311		
Other	1.3 (0.6–2.9)	0.508		
Have a regular partner				
Yes	0.7 (0.5–0.9)	0.040	1.1 (0.8–1.7)	0.541
No	Ref			
Find sexual partner through social apps				
Yes	2.4 (1.8–3.3)	<0.001	2.5 (1.7–3.7)	<0.001
No	Ref			
Time since HIV diagnosis				
<12 months	Ref			
13–35 months	1.0 (0.7–1.6)	0.970		
≥36 months	1.4 (0.9–2.1)	0.132		
Viral load of HIV in the last year				
Detectable	Ref			
Undetectable	2.4 (1.6–3.6)	<0.001	2.1 (1.3–3.3)	0.001
Not sure	1.8 (1.1–3.0)	0.029	1.3 (0.7–2.3)	0.384
Taking HIV medications				
Yes	Ref			
No	0.5 (0.3–1.0)	0.067	0.5 (0.3–1.1)	0.072
Recreational drug use before or during sexual activities				
Yes	Ref			
No	0.8 (0.6–1.2)	0.294		
Alcohol use before or during sexual activities				
Yes	2.2 (1.6–3.0)	<0.001	1.7 (1.2–2.4)	0.001
No	Ref			
Circumcised				
Yes	0.4 (0.3–0.6)	<0.001	0.6 (0.4–0.8)	0.002
No	Ref			

Abbreviations: OR=odds ratio; CI=confidence interval; Ref=reference; HIV=human immunodeficiency virus; MSM=men who have sex with men.

partners, who were also at the risk of STIs and infection of HIV of a different genotype. Therefore, condom use is necessary in oral sex among HIV-infected individuals, especially when they receive oral sex and ejaculate in their partner's mouth.

The findings suggested that HIV-infected MSM who found sexual partners through social apps were more likely to engage in oral sex without a condom. A previous study showed that HIV-positive MSM were more likely to engage in high-risk sexual behaviors in the context of casual sex encounters than in steady sexual relationships (*8*). A possible explanation is that casual partners who meet through social apps, will not be informed of the HIV status of participants during oral sex, so they are more likely to engage in oral sex without a condom due to their negligence of the risk of this sexual practice. This study supported the integration of social apps commonly used by MSM into sexual health education. In addition, the results of this study also showed that alcohol drinking before or during sexual activity was significantly related to the use of condoms in oral sex of HIV-infected MSM. People under the influence of alcohol may become disinhibited and are more likely to engage in risky sexual behaviors (*9*). This study emphasized the need to implement alcohol risk reduction programs in HIV-infected MSM.

A previous study showed that 85% of HIV-infected MSM reported having oral sex without a condom, which was similar to the finding of this study (*5*). A qualitative study among HIV-infected MSM showed that in the absence of information about whether oral sex posed a significant risk of HIV transmission, HIV-infected MSM would give up condom use during oral sex but were usually accompanied by anxiety (*10*).

The study was subject to at least four limitations. First, the convenience sampling might produce selection bias and might not represent the entire HIV-infected MSM in China. Second, the partner's serostatus was not mentioned in the questionnaire. Third, the cross-sectional data in this study may be subject to potential recall bias and could not establish a causal relationship. Fourth, information on STIs history were not collected, so the connection between oral sex and STIs were unable to be evaluated.

HIV-infected MSM should be informed of the potential risk of unprotected oral sex. Targeted educational strategies and interventions are needed for HIV-infected MSM to minimize the risk of unprotected oral sex. The public health sectors in China should recommend condom use during oral sex among HIV-infected MSM, especially when in-mouth ejaculation is involved.

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REFERENCES

1. Centers for Disease Control and Prevention. STD risk and oral sex - CDC fact sheet. 2022. https://www.cdc.gov/std/healthcomm/STDFact-STDRiskAndOralSex.htm. [2022-3-22]
2. Robbins SJ, Dauda W, Kokogho A, Ndembi N, Mitchell A, Adebajo S, et al. Oral sex practices among men who have sex with men and transgender women at risk for and living with HIV in Nigeria. PLoS One 2020;15(9):e0238745. http://dx.doi.org/10.1371/journal.pone.0238745.
3. Bruce D, Harper GW, Fernández MI, Jamil OB. Age-concordant and age-discordant sexual behavior among gay and bisexual male adolescents. Arch Sex Behav 2012;41(2):441 – 8. http://dx.doi.org/10.1007/s10508-011-9730-8.
4. Weng RX, Hong FC, Yu WY, Cai YM. Compare HIV/syphilis infections between age groups and explore associated factors of HIV/syphilis co-infections among men who have sex with men in Shenzhen, China, from 2009 to 2017. PLoS One 2019;14(10):e0223377. http://dx.doi.org/10.1371/journal.pone.0223377.
5. Sirivongrangson P, Lolekha R, Charoenwatanachokchai A, Siangphoe U, Fox KK, Jirarojwattana N, et al. HIV risk behavior among HIV-infected men who have sex with men in Bangkok, Thailand. AIDS Behav 2012;16(3):618 – 25. http://dx.doi.org/10.1007/s10461-011-

9884-3.
6. Zheng WR, Sun YH, Li H, Zhao HP, Zhan YW, Gao YS, et al. COVID-19 vaccine uptake and hesitancy among HIV-infected men who have sex with men in mainland China: a cross-sectional survey. Hum Vaccines Immunother 2021;17(12):4971 – 81. http://dx.doi.org/10.1080/21645515.2021.1996152.
7. Politch JA, Mayer KH, Welles SL, O'brien WX, Xu C, Bowman FP, et al. Highly active antiretroviral therapy does not completely suppress HIV in semen of sexually active HIV-infected men who have sex with men. AIDS 2012;26(12):1535 – 43. http://dx.doi.org/10.1097/QAD.0b013e328353b11b.
8. van Kesteren NMC, Hospers HJ, van Empelen P, van Breukelen G, Kok G. Sexual decision-making in HIV-positive men who have sex with men: how moral concerns and sexual motives guide intended condom use with steady and casual sex partners. Arch Sex Behav 2007;36(3):437 – 49. http://dx.doi.org/10.1007/s10508-006-9125-4.
9. Semple SJ, Patterson TL, Grant I. HIV-positive gay and bisexual men: predictors of unsafe sex. AIDS Care 2003;15(1):3 – 15. http://dx.doi.org/10.1080/713990434.
10. Vanable PA, Carey MP, Brown JL, Littlewood RA, Bostwick R, Blair D. What HIV-positive MSM want from sexual risk reduction interventions: findings from a qualitative study. AIDS Behav 2012;16(3):554 – 63. http://dx.doi.org/10.1007/s10461-011-0047-3.

Preplanned Studies

Factors that Affect the Frequency of HIV Testing in College Men Who Have Sex with Men — Northeast China, 2017–2018

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Summary

What is already known about this topic?

Human immunodeficiency virus (HIV) testing is a critical tool in reducing HIV transmission among men who have sex with men (MSM); young MSM frequently use mobile phone applications and participate in social hook-ups.

What is added by this report?

The prevalence of HIV testing-frequency (≥2) over the whole study period (15 months) was 38.6% among college MSM in Northeast China. MSM with more social contacts, recreational drug use, and prior HIV self-test experience (reported via mobile phone geo-social apps) were more likely to have higher offline HIV testing frequency.

What are the implications for public health practice?

A gay-oriented app provides opportunities for online interventions to promote HIV testing services.

Given the burden of unrecognized infections contributing to human immunodeficiency virus (HIV) transmission, HIV cases finding among men who have sex with men (MSM) identify HIV testing as prerequisite entry points for treatment and Pre-Exposure Prophylaxis (PrEP) (*1*). HIV testing promotion is a critical "first step" prevention strategy to engage young MSM (YMSM) and testing should be conducted more than once each year (*2*). The benefits of providing more frequent testing (e.g., once every 3 or 6 months) can include risk reduction and early diagnosis to reduce local HIV transmission (*3*). Online social networks have made social and sexual hook-ups more efficient for YMSM (*4*). Geo-social network application (app) use may concurrently have manifestations of sexual risk behaviors and risk-reduction behaviors such as increased HIV testing (*5*). Understanding social networks among MSM attending college can inform HIV testing strategies in a population documented to be at risk. We established a prospective longitudinal study to identify the association and magnitude of social contacts with HIV testing among 759 college MSM as users of the Yiyou App in Northeast China from April 2017 to June 2018. Higher HIV testing-frequency in the voluntary counseling and testing (VCT) site was more likely among men with recreational drug use [adjusted odds ratio (aOR)=1.7, 95% confidence interval (CI): 1.0–2.7], having ≥1 HIV self-test (aOR=2.7, 95% CI: 1.9–4.0), ≥1 social contact (aOR=4.1, 95% CI: 2.7–6.2) in cross-sectional analysis, and ≥1 social contact (aOR=3.8, 95% CI: 2.4–6.0) in longitudinal analysis.

The prospective longitudinal study used online survey data retrieved from the Yiyou App supported by the Heilongjiang Kangtong Community (HKC), the largest community-based organization focused on serving MSM in Northeast China. We then linked survey data to HKC's offline services data. We approached 3,698 potentially eligible registered users of Yiyou App from 21 HKC collaborated VCT sites, among whom 759 (20.5%) college MSM were screened, enrolled, and completed our survey from April 2017 to June 2018. Inclusion criteria were: 1) biological males at least 18 years old and schooling in colleges; 2) self-reported ever had sex with men; 3) willing to provide blood samples for HIV/syphilis testing; 4) able to understand and complete the questionnaire interview; and 5) physically capable and willing to consent online. A total of 382 non-student participants (10.3% of 3,698) were enrolled from the same pool as social contacts of the 759 students. A self-administrated structured questionnaire was conducted on sociodemographic information, perceived risk of HIV infection, sexual behaviors, recreational drug use in the past 6 months, and HIV self-test experience. There was an option to choose the identity as a student or not to declare college student identity. Upon completion of the online survey, participants were asked to undertake dual rapid HIV and syphilis tests and a parallel rapid HIV test by trained workers in offline VCT sites. Participants having positive HIV rapid results have their HIV status confirmed via Western blot at the provincial CDC and then referred for HIV care and antiretroviral therapy (ART). All participants were followed up for at least one month over the whole study period (15 months).

The outcome indicator was the HIV testing frequency of the college MSM in VCT sites during the study period. The main predictors studied using the online survey data were the number of social contacts, which was limited to the approached 3,698 registered users pool. We generated logistic regression models and generalized estimating equations (GEE) models to determine the association of HIV testing frequency with sexual behaviors and social contacts among college MSM. Microsoft Excel (Microsoft®, Albuquerque, New Mexico, USA) and Statistical Analysis System (version 9.4, SAS Institute Inc., Cary, North Carolina, USA) were used to manage the dataset and conduct the analyses.

Of 759 participating college MSM, the median age was 22 years old [interquartile range (IQR)=20–26]. Among 759 college MSM, 1,385 cumulative HIV tests were reported with 141 (18.6%) having had >2 HIV tests (repeated tests=615), 152 (20.0%) having two HIV tests (repeated tests=304) and 466 (61.4%) having one test. Hence, 293 (38.6%) had higher HIV testing-frequency (≥2) in the VCT site accounting for 170.50 person-years during the 15-month study period. Among 1,385 cumulative HIV tests, 34 participants with positive results were confirmed and referred to treatment. According to the cross-sectional analysis (model 1), those with more HIV testing (≥2) were more likely to be older (>23 years old; aOR=2.5, 95% CI: 1.8–3.6); have resided for shorter (<1 years, aOR=4.7, 95% CI: 2.6–8.4) in the survey cities; had recreational drug use in the past 6 months (aOR=1.7, 95% CI: 1.0–2.7); have ≥1 HIV self-test (aOR=2.7, 95% CI: 1.9–4.0); and have ≥1 social contacts (aOR=4.1, 95% CI: 2.7–6.2; Table 1). For the longitudinal analysis (model 2), men having ≥1 social contacts (aOR=3.8, 95% CI: 2.4–6.0) were more likely to have >2 HIV tests (Table 2).

DISCUSSION

We used App-derived data to explore the association of HIV testing frequency with social contacts, finding that college MSM with more social contacts (≥1) were more likely to have more HIV testing (≥2 in cross-sectional analysis, >2 in longitudinal analysis) in Northeast China. Relative social isolation among MSM may, in contrast, result in lower HIV testing frequency. Moreover, we found that college MSM who were older (>23 years), non-local (lived <1 year), used recreational drugs, had anal sex in the past six months, and had HIV self-tested were more likely to take subsequent HIV tests. These findings raised the prospect that themed apps can be used to deliver tailored interventions, such as sending reminders for repeated testing and information about ART and promoting safer sexual behaviors in following stages of the ongoing study.

Low awareness of HIV testing has been reported in the Chinese MSM community (*6*), especially among the college YMSM. Those who were shorter-term residents of the surveyed city were more likely to have HIV testing; it may be more challenging for migrants to access testing information and HIV prevention intervention programs offline than online (*6*). Mobile apps can play an important facilitative role in improving access to testing and health information, especially among persons recently arriving on a college campus. The syndemic of high-risk sexual behavior and recreational drug use helps drive HIV transmission through higher-risk sexual behaviors (*7*). We found that YMSM who had anal sex or had used recreational drugs in the past 6 months were more likely to have more frequent subsequent HIV tests in univariate longitudinal analysis. The true effect may be even greater than measured here since higher-risk YMSM who become HIV-infected are then not tested once infection is confirmed. Therefore, social media apps can usher in a new era of more accessible and available educational and linkage services for hidden populations.

More social contacts may indicate that YMSM willing to share their social information are more likely to internalize their sexual orientation. We speculated that this willingness to share may indicate better coping with stigmatization and an ability to overcome initial reluctance to use HIV testing services (*8*). MSM having more social interactions with others were more likely to obtain HIV testing, a consistent observation in several countries (*9*). YMSM may be more easily influenced by social contacts, particularly one who exhibits trust by disclosing his sexual orientation (*8*). Social system theory suggests that social networks can affect HIV testing behavior via information sharing that facilitates actions in decision-making and

TABLE 1. Predictors of higher HIV testing-frequency (≥2) among 759 college men who have sex with men in Northeast China, 2017–2018 (N=759): a logistic regression model.

Factors	Higher HIV testing-frequency (≥2) n (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Age (years)			
≤23	131 (28.0)	1	1
>23	147 (56.8)	3.38 (2.5–4.6)*	2.52 (1.8–3.6)*
Ethnicity			
Minority	8 (36.4)	1	
Han	285 (38.7)	1.11 (0.5–2.7)	
Marital status			
Unmarried	281 (38.5)	1	
Married	11 (44.0)	1.25 (0.6–2.8)	
Residence			
Other cities/PLADs	127 (37.8)	1	
Local	166 (39.3)	1.07 (0.8–1.4)	
Time spent locally (months)			
12–24	34 (20.7)	1	1
<12	69 (54.8)	4.63 (2.8–7.7)*	4.67 (2.6–8.4)*
>24	190 (40.6)	2.61 (1.7–4.0)*	2.36 (1.4–3.9)*
Perceived risk of HIV infection			
High-very high	21 (38.2)	1	
Moderate	56 (32.7)	0.79 (0.4–1.5)	
No-low	216 (40.5)	1.10 (0.6–2.0)	
Having anal sex in the past 6 months			
No	120 (36.4)	1	1
Yes	171 (45.5)	1.46 (1.1–2.0)*	0.88 (0.6–1.3)
Condom use with male partners in the past 6 months			
Never	9 (39.1)	1	
Sometimes	64 (36.8)	0.91 (0.4–2.2)	
Every time	98 (54.7)	1.88 (0.8–4.6)	
Number of regular partners in the past 6 months			
0	25 (52.1)	1	
1	100 (43.3)	0.70 (0.4–1.3)	
2	35 (47.3)	0.83 (0.4–1.7)	
≥3	11 (47.8)	0.84 (0.3–2.3)	
Any recreational drug use in the past 6 months			
No	217 (35.1)	1	1
Yes	76 (54.7)	2.24 (1.5–3.2)*	1.66 (1.0–2.7)*
Ever had HIV self-test			
No	141 (33.3)	1	1
Yes	150 (53.2)	2.28 (1.7–3.1)*	2.72 (1.9–4.0)*
Number of social contacts			
0	169 (28.8)	1	1
≥1	124 (71.7)	6.24 (4.3–9.1)*	4.07 (2.7–6.2)*

Note: All 6 variables with $P \leq 0.05$ in univariate analysis were included in multivariate analysis.
Abbreviations: HIV=human immunodeficiency virus; CI=confidence interval; PLAD=provincial-level administrative divisions.
* $P \leq 0.05$.

TABLE 2. Predictors of higher HIV testing-frequency (>2) among 759 college men who have sex with men in Northeast China, 2017–2018 (Cumulative HIV tests N=1,385): a GEE model.

Factors	Higher HIV testing-frequency (>2) n (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Having anal sex in the past 6 months			
No	199 (36.1)	1	1
Yes	414 (53.1)	2.01 (1.4–2.8)*	1.37 (1.0–2.0)
Any recreational drug use in the past 6 months			
No	431 (40.2)	1	1
Yes	183 (58.7)	2.11 (1.4–3.1)*	1.28 (0.8–1.9)
Ever had HIV self-test			
No	356 (42.5)	1	1
Yes	254 (51.8)	1.45 (1.1–2.0)*	1.28 (0.9–1.8)
Number of social contact			
0	270 (30.3)	1	1
≥1	345 (69.8)	5.33 (3.5–8.1)*	3.81 (2.4–6.0)*

Note: Adjusted model additionally includes categorized age, time spent locally, a total of 6 independent variables in comparison with Table 1.
Abbreviations: HIV=human immunodeficiency virus; GEE=generalized estimating equations; CI=confidence interval.
* $P \leq 0.05$.

problem-solving (*10*). We interpreted our findings to support a hypothesis that more social contact is associated with a higher chance of HIV testing. An alternative hypothesis is that socially engaged men are taking more risks and therefore obtaining more tests.

Limitations included our inability to generalize our findings outside of Northeast China or areas where the Yiyou App is not used. Since the app is not for “hook-up” per se, but rather designed for sero-sorting assistance, we cannot generalize our findings to all gay-themed Apps. Moreover, some users may use a different phone number for connecting with a “digital bathhouse” due to a stigmatization of homosexuality in China and/or men may delete contacts after sex encounters; therefore, social contact information could be biased towards a minimum estimate in terms of numbers, density, and/or breadth of their sexual networks.

This study highlighted the potential for online social interventions to promote HIV testing and relevant services. Governmental agencies should introduce policies to encourage themed apps to establish HIV testing information through real-time inquiry systems. MSM community organizations should provide more peer support or HIV self-test resources to available public service departments. And for college MSM, risk-reduction behaviors, such as HIV testing every 3 months, should be encouraged.

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REFERENCES

1. He N. Research progress in the epidemiology of HIV/AIDS in China. China CDC Wkly 2021;3(48):1022 – 30. http://dx.doi.org/10.46234/ccdcw2021.249.
2. Pitasi MA, Delaney KP, Oraka E, Bradley H, DiNenno EA, Brooks JT, et al. Interval since last HIV test for men and women with recent risk for HIV infection - United States, 2006-2016. MMWR Morb Mortal Wkly Rep 2018;67(24):677 – 81. http://dx.doi.org/10.15585/mmwr.mm6724a2.
3. DiNenno EA, Prejean J, Irwin K, Delaney KP, Bowles K, Martin T, et al. Recommendations for HIV screening of gay, bisexual, and other men who have sex with men - United States, 2017. MMWR Morb Mortal Wkly Rep 2017;66(31):830 – 2. http://dx.doi.org/10.15585/

mmwr.mm6631a3.
4. Phanuphak N, Anand T, Jantarapakde J, Nitpolprasert C, Himmad K, Sungsing T, et al. What would you choose: online or offline or mixed services? Feasibility of online HIV counselling and testing among Thai men who have sex with men and transgender women and factors associated with service uptake. J Int AIDS Soc 2018;21 Suppl 5(Suppl 5):e25118. http://dx.doi.org/10.1002/jia2.25118.
5. Wei L, Chen L, Zhang HB, Yang ZR, Zou HC, Yuan TW, et al. Use of gay app and the associated HIV/syphilis risk among non-commercial men who have sex with men in Shenzhen, China: a serial cross-sectional study. Sex Transm Infect 2019;95(7):496 – 504. http://dx.doi.org/10.1136/sextrans-2018-053902.
6. Wu HC, Xiu CZ, Fu XJ, Li ML, Wang ZH, Li XF, et al. Syphilis associated with recreational drug use, depression and high-risk sexual behaviour in men who have sex with men: a case-control study in China. Sex Transm Infect 2019;95(4):267 – 72. http://dx.doi.org/10.1136/sextrans-2018-053878.
7. Basten M, Heijne JCM, Geskus R, Den Daas C, Kretzschmar M, Matser A. Sexual risk behaviour trajectories among MSM at risk for HIV in Amsterdam, the Netherlands. AIDS 2018;32(9):1185 – 92. http://dx.doi.org/10.1097/QAD.0000000000001803.
8. Cao BL, Saffer AJ, Yang C, Chen HX, Peng K, Pan SW, et al. MSM behavior disclosure networks and HIV testing: an egocentric network analysis among MSM in China. AIDS Behav 2019;23(5):1368 – 74. http://dx.doi.org/10.1007/s10461-019-02404-z.
9. Tanner AE, Song EY, Mann-Jackson L, Alonzo J, Schafer K, Ware S, et al. Preliminary impact of the weCare social media intervention to support health for young men who have sex with men and transgender women with HIV. AIDS Patient Care STDS 2018;32(11):450 – 8. http://dx.doi.org/10.1089/apc.2018.0060.
10. Hermanstyne KA, Green HD Jr, Cook R, Tieu HV, Dyer TV, Hucks-Ortiz C, et al. Social network support and decreased risk of seroconversion in black MSM: results of the BROTHERS (HPTN 061) study. J Acquir Immune Defic Syndr 2018;78(2):163 – 8. http://dx.doi.org/10.1097/QAI.0000000000001645.

Methods and Applications

Estimating Costs of the HIV Comprehensive Intervention Using the Spectrum Model — China, 2015–2019

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ABSTRACT

Introduction: In order to facilitate human immunodeficiency virus (HIV) treatment and prevention, the resource needs for HIV national strategic planning in developing regions were estimated based on Spectrum, the universal HIV cost-effectiveness analysis software.

Methods: Based on the theoretical framework of Spectrum, the study developed a cost measurement tool for HIV, and calculated the cost of HIV prevention and control in 6 sampled cities in China during 2015–2019 using the Spectrum model.

Results: From 2015 to 2019, the average annual costs for HIV prevention and control for Shijiazhuang, Yantai, Ningbo, Zhenjiang, Foshan, and Wuxi cities were 46.78, 47.55, 137.49, 24.73, 74.37, and 58.30 million Chinese yuan (CNY), respectively. The per capita costs were 4.37, 6.73, 17.33, 7.77, 17.56, and 8.91 CNY, respectively. In terms of the cost structure, the ratio of preventive intervention funds to therapeutic intervention funds (antiviral treatment) varied in sampled cities.

Discussion: Developing comprehensive and systematic HIV fund calculation methods can provide a research basis for rational resource allocation in the field of HIV.

INTRODUCTION

As China is striving to meet the Joint United Nations Programme on HIV/AIDS (UNAIDS) 90-90-90 targets, tracking and estimating resource needs is critical in informing financial decisions for human immunodeficiency virus (HIV) prevention and control programs.

Comprehensive HIV prevention and treatment covers various target populations, such as the general population, high-risk groups, infected persons, and a series of service providers including social organizations, community health institutions, CDCs, and hospitals. Sources of funding for prevention and treatment programs include the central government, local government, charitable funds, cooperation projects, and out-of-pocket payments from individuals. The diversity of service objectives, service providers, and funding sources leads to many uncertainties in regional HIV cost calculations.

Based on the theoretical framework of the international HIV cost-effectiveness analysis software Spectrum (*1*–*2*), our group developed a cost measurement and investigation tool for HIV (*3*) and calculated the cost of HIV prevention and control from the perspective of service suppliers. This was established by collecting and investigating the size of various populations, the actual coverage of various HIV interventions, and the unit cost of services. We estimated the cost of comprehensive HIV intervention in Shijiazhuang City from 2015 to 2019 (*4*). Then, based on this, we measured the HIV intervention costs of 6 cities in eastern China and compared the total costs and the composition change of HIV comprehensive intervention among these cities.

METHODS

The eastern cities of China are economically developed areas with dense populations in the secondary and tertiary sectors, large population mobility, many groups at high risk for HIV, and have better HIV intervention coverage and epidemiological records. Overall, 5 cities in eastern China including Shijiazhuang, Yantai, Ningbo, Foshan, and Wuxi (hereafter, these cities will be abbreviated as S, Y, N, F, and W, respectively) were selected according to 2 conditions: the total population was more than 3 million and the number of newly reported cases of HIV infection was more than 200 each year. In order to increase the representativeness of urban samples, the research group added Zhenjiang City (in this paper will be abbreviated as Z; locates in Jiangsu Province, the same as Wuxi City) with a population of 3 million and 50 newly reported cases of HIV infection each year.

Data was collected on population size, prevention of mother-to-child transmission (PMTCT), antiretroviral treatment (ART), population comprehensive prevention coverage and cost measurement, and program support. CDCs, designated treatment hospitals, and maternal and child health centers provided relevant quantitative data. If some unit costs were missing in one sampled city, we adopted the average value of available cities. If there were outliers (where the unit cost was drastically different from that in other cities), we used the average value of the cities with reasonable values. The coverage of each HIV intervention service in each city collected in this study was completely subject to the results reported and checked by the six cities.

There were three sub-modules, including Demographic Model (Demproj), AIDS Impact Model (AIM), and Resource Needs Model (RNM), used for comprehensive evaluation of HIV interventions under Spectrum. DemProj Module was used to perform demographic projections by age and sex according to past fertility, mortality, and migration rates. The AIM Module was used to estimate HIV prevalence. RNM was used to generate cost estimates of various interventions (*5*). The employed coverages and unit costs were part of our previous work.

TABLE 1. Average annual coverage of HIV interventions in 6 cities from 2015–2019 (in person-time).

HIV intervention	S	Y	N	Z	F	W
Prevention						
Priority populations						
Youth focused interventions	3,150	0	46,369	243	32,330	1,426
Female sex workers and clients	2,131	1,538	18,646	2,985	10,641	6,072
Male sex workers and clients	62	0	0	0	0	0
Cash transfers	N/A	N/A	N/A	N/A	N/A	N/A
Injecting drug users	0	0	0	992	0	0
MSM	4,315	3,409	8,131	1,247	23,205	7,660
Community mobilization	255,351	196,606	376,180	857,149	199,889	171,267
Service delivery						
Condom provision	N/A	N/A	N/A	N/A	N/A	N/A
STI management	617	564	5,911	67	8,859	1,096
VCT	21,198	13,519	16,379	6,739	4,631	4,860
PrEP	0	0	0	0	0	0
PMTCT	2	1	4	1	4	5
Mass media	829,720	1,255,575	839,149	97,008	207,673	N/A
Health care						
Blood safety	294,311	595,350	N/A	N/A	N/A	74,229
PEP	0	67	552	0	0	0
Safe injection	N/A	N/A	N/A	N/A	N/A	N/A
Universal precautions	54,781	41,293	32,593	14,703	30,786	34,260
Care and treatment services						
ARV therapy	1,379	673	3,251	815	1,982	398
Non-ART care and prophylaxis	608	371	626	153	527	696

Note: N/A indicates missing data. The 6 cities includes Shijiazhuang, Yantai, Ningbo, Zhenjiang, Foshan, and Wuxi, abbreviated as S, Y, N, Z, F, and W, respectively.

Abbreviations: HIV=Human immunodeficiency virus; MSM=Men who have sex with men; STI=Sexually transmitted infections; VCT=Voluntary counseling and testing; PrEP=Pre-exposure prophylaxis; PMTCT=Prevention of mother-to-child transmission; PEP=Post-exposure prophylaxis; ARV=AIDS-related virus; ART=Antiretroviral therapy.

RESULTS

Table 1 showed that for 2015–2019, routine HIV interventions in cities S, Y, N, Z, F, and W mainly included youth, female sex workers, and men who have sex with men (MSM) focused interventions, community mobilization, condom provision, sexually transmitted infection (STI) management, voluntary counseling and testing (VCT), PMTCT, mass media, blood safety, safe injection, universal precautions, and antiretroviral therapy (ARV). The coverage related to the interventions of condom promotion, blood safety, and safe injection was unavailable because their administration departments involved other departments, such as local Family Planning Department, blood bank, and hospital.

In order to make the costs more comparable, the gross domestic product (GDP) deflators of the six cities were obtained by referring to the regional GDP index (Supplementary Table S1, available in http://weekly.chinacdc.cn/). The 2019 GDP deflator was adopted to modify the projected costs. Then, the total and average annual cost of each intervention for each city was calculated.

There was an imbalance in the total costs and per-capita of HIV funds among cities (Table 2). From 2015 to 2019, the average annual costs of S, Y, N, Z, F, and W were 46.78 million Chinese yuan (CNY), 47.55 million CNY, 137.49 million CNY, 24.73 million CNY, 74.37 million CNY, and 58.30 million CNY, respectively. The per capita costs were 4.37 CNY, 6.73 CNY, 17.33 CNY, 7.77 CNY, 17.56 CNY, and 8.91 CNY, respectively. City N had the largest cost input in all service categories including priority population, service delivery, health care, treatment services and program support. City N reached 17.37 CNY per capita, city F reached 17.56 CNY per capita, and city S reached 4.37 CNY per capita. We plotted the three categories of cost results (prevention, treatment, and program support) displayed by Spectrum and calculated the cost ratio of preventive and therapeutic interventions.

Figure 1 showed that the comparable per capita cost of HIV finance increased steadily during 2015–2019 in all 6 cities. City N started at a high level and continued improving rapidly. The total cost ratio of prevention to treatment in 6 cities decreased from 0.79 in 2015 to 0.58 in 2019. The 6 cities had different manifestations in the cost changes for prevention and treatment interventions: 1) fluctuating: in city Y, the funds for prevention and treatment were in a stable fluctuating state. The ratio of prevention/treatment expenditure was around 1.8–1.4; 2) rapid increase in ARV: in city N, the investment of preventive intervention funds was stable, the cost of ARV funds increased from 24.79 million CNY in 2015 to 69.51 million CNY in 2019, and the ratio of prevention to treatment funds showed a rapid downward trend (from 1.25 in 2015 to 0.50 in 2019); 3) steady increase in ARV: in city Z, F, and W, the investment of preventive intervention funds was stable, the cost of ARV funds increased steadily, and the ratio of prevention/treatment funds showed a steady downward trend (from 0.88, 0.92, and 0.54 in 2015 to 0.59, 0.72, and 0.42 in 2019); 4) synchronous growth type: in city S, prevention and treatment funds maintained a synchronous growth trend (from 0.13 in 2015 to 0.20 in 2019).

DISCUSSION

A mature model with standardized data collection and information processing can generate more reliable estimates. Through standardized reports, the research results are reliable for decision-makers (*6*–*7*). Particularly, it may help to reasonably estimate the resources needed to expand, maintain, or replicate successful interventions at a local or national level.

Multiple data collection sources and incomplete information greatly increased the complexity of HIV disease-tracking modeling. Data reported by different departments and institutions may often conflict with each other. Developed jointly by the United Nations Programme on HIV/AIDS and other national teams, Spectrum software can estimate the cost of HIV/AIDS based on the mathematical model established by regional HIV/AIDS epidemic data and intervention program coverage (*8*). This provides a tool to calculate and compare HIV funds among subnational regions in China.

Our research reflected that HIV prevention and control funds continued to grow, but there was a regional imbalance in sampled cities. Based on the data of 2019, the comparable HIV intervention total cost in 6 cities adjusted by the GDP deflator showed an upward trend, indicating that each city had continuously increased investment in HIV prevention and control. In the most economically developed provinces, Guangdong and Zhejiang, the HIV prevention and control costs of the sampled cities were significantly higher than those of other cities.

TABLE 2. Costs of HIV interventions in 6 cities from 2015–2019 (in million CNY).

Cost for HIV Intervention	S	Y	N	Z	F	W
Prevention	7.29	27.90	33.96	8.95	30.26	16.15
Priority populations	0.96	2.61	14.80	0.88	14.61	4.76
Youth focused interventions	0.19	0.00	2.54	0.04	2.83	0.12
Female sex workers and clients	0.04	0.02	1.96	0.01	0.53	0.62
Male sex workers and clients	0.00*	0.00	0.00	0.00	0.00	0.00
Cash transfers	0.00	0.00	0.00	0.00	0.00	0.00
Injecting drug users	0.00	0.00	0.00	0.59	0.00	0.00
MSM	0.41†	0.37	0.85	0.07	1.23	0.98
Community mobilization	0.32	2.23	9.45	0.17	10.01	3.03
Service delivery§	1.59	4.78	12.15	2.96	6.89	1.54
Condom provision§	204.54	30.45	18.09	5.72	139.80	111.72
STI management	0.40	0.30	7.21	0.03	6.10	0.56
VCT	0.94	4.28	4.82	2.86	0.36	0.98
Male circumcision	0.00	0.00	0.00	0.00	0.00	0.00
PrEP	0.00	0.00	0.00	0.00	0.00	0.00
PMTCT§	8.37	0.08	0.76	0.18	1.51	0.04
Mass media	0.26	0.20	0.12	0.07	0.43	0.00
Health care§	4.74	20.51	7.01	5.11	8.76	9.85
Blood safety§	110.40	35.55	N/A	N/A	N/A	6.02
PEP	0.00	0.17	0.15	0.00	0.00	0.00
Safe injection	N/A	N/A	N/A	N/A	N/A	N/A
Universal precautions	4.74	20.34	6.86	5.11	8.76	9.85
Care and treatment services	37.16†	17.58	50.90	13.06	36.95	34.67
ARV therapy	17.06†	8.47	33.58	7.77	18.47	9.43
Non-ART care and prophylaxis	20.10†	9.10	17.32	5.30	18.48	25.25
Program support§	2.32	2.08	52.64	2.71	7.16	7.48
Enabling environment	0.00	0.00	0.00	0.00	0.00	0.00
Program management	1.28	0.71	44.40	0.80	0.93	5.19
Research	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring and evaluation	0.04	0.07	0.00	0.07	0.12	0.41
Strategic communication	0.00	0.00	0.00	0.00	0.00	0.00
Logistics	0.06	0.37	5.92	0.41	3.08	0.83
Program-level HR	0.81	0.85	2.28	1.34	2.30	0.90
Training	0.13	0.07	0.04	0.10	0.73	0.15
Laboratory equipment§	1.36	2.8	3.01	27.11	30.97	N/A
Total millions of CNY§	46.78	47.55	137.49	24.73	74.37	58.30
Total populations	10,699,314	7,065,362	7,936,082	3,183,832	4,235,791	6,543,320
Per capita HIV intervention cost (CNY)	4.37	6.73	17.33	7.77	17.56	8.91
Cost ratio of prevention to treatment	0.20	1.59	0.67	0.69	0.82	0.47

Note: N/A indicates missing data. The 6 cities includes Shijiazhuang, Yantai, Ningbo, Zhenjiang, Foshan, and Wuxi, abbreviated as S, Y, N, Z, F, and W, respectively.

Abbreviations: HIV=Human immunodeficiency virus; CNY=Chinese yuan; MSM=Men who have sex with men; STI=Sexually transmitted infection; VCT=Voluntary counseling and testing; PrEP=Pre-exposure prophylaxis; PMTCT=Prevention of mother-to-child transmission; PEP=Post-exposure prophylaxis; ARV=AIDS-related virus; ART=Antiretroviral therapy; HR=Human resource.

* The cost of male sex workers and clients in city S was not 0, but 2,654 CNY.

† The unit cost of this indicator in city S was quite different from the other cities, therefore, the average value of other cities filled in the unit cost had been taken.

§ To ensure the comparability of total costs in all cities, i.e., all sub cost items in 6 cities were the same, the total costs in this study were not including the costs of condom provision, PMTCT, blood safety, and laboratory equipment.

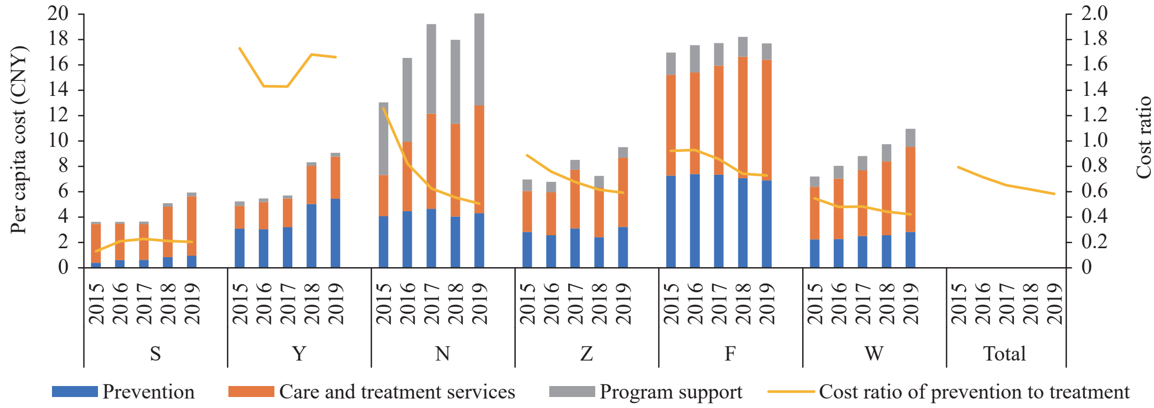

FIGURE 1. Per capita cost and cost ratio of prevention to treatment of 6 cities from 2015 to 2019.
Note: The 6 cities include Shijiazhuang, Yantai, Ningbo, Zhenjiang, Foshan, and Wuxi, abbreviated as S, Y, N, Z, F, and W, respectively.
Abbreviation: CNY=Chinese yuan.

Our research suggested that it is necessary to explore the correlation among preliminary work indicators, fund allocation, and subsequent intervention coverage and quality in the future. Differentiating reasonable and unreasonable factors of regional resource allocation will help to provide evidence for equitable and efficient resource allocation (*9*).

The distribution structure of funds for prevention and treatment must be balanced. With the continuous scaling-up of ARV, post-exposure prophylaxis (PEP), pre-exposure prophylaxis (PrEP), and other proven effective therapeutic interventions, investment in this area has increased rapidly worldwide. From 2015 to 2019, it was determined that HIV funding in these 6 cities was mainly due to the rapid growth of ARV costs. Evidence from the past 40 years indicated that scientific innovation, research, funding, activism, and policies were all central components of HIV messaging in ending HIV (*10*). It is necessary to simulate the list of prioritized interventions with high cost-effectiveness combined with the local population size, characteristics and HIV epidemic trend. An optimized HIV resource reallocation model may provide a reference for future intensive HIV investments (*11*–*14*).

This study was subject to some limitations. First, in the current tool, the costs were classified according to intervention services, which was different from the actual situation. For example, the provision of condoms involved multiple departments. It was difficult to collect multi-source data and may have resulted in underestimating related costs. In future studies, cost measurement tools consistent with the implementation will be more operable and more accurate. Second, the current cost measurement tool were still difficult to distinguish between the quantity and quality of HIV interventions and quantify each dimension. For example, there are great differences between the number of people receiving standardized STI management coverage and the number of people receiving STI treatment. This study estimated the cost according to the former indicators, which may have underestimated the total expenditure of STI treatment and management. The distinction and quantification of the “quality” and “quantity” of HIV intervention will increase the accuracy of cost estimation in the next step.

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REFERENCES

1. Avenir Health. Spectrum Manual: Spectrum System of Policy Models. http://avenirhealth.org/Download/Spectrum/Manuals/SpectrumManualE.pdf. [2021-6-26].
2. Stover J, Glaubius R, Mofenson L, Dugdale CM, Davies MA, Patten G, et al. Updates to the Spectrum/AIM model for estimating key HIV indicators at national and subnational levels. AIDS 2019;33(S3):S227 – 34. http://dx.doi.org/10.1097/QAD.0000000000002357.
3. Jiang Z, Zhang YR, Wang LL, Wu ZY. Exploration on the cost estimation tool for HIV comprehensive health intervention according to spectrum theoretical framework. Chin Health Econ 2021;40(3):61 – 5. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2021&filename=WEIJ202103021. (In Chinese).
4. Zhang YR, Qiu YC, Wang LL, Liu XS, Liang L, Liu LH, et al. The cost estimation of HIV comprehensive prevention and control intervention based on the 2015-2019 data in Shijiazhuang. Chin Health Econ 2021;40(3):66 – 71. https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2021&filename=WEIJ202103022&uniplatform=NZKPT&v=XQwDXiypy0ErhLzikXJxM-X2lzlI4iGB4ySG2ty11ektUAck_plckOfxk-wgtDCv. (In Chinese).
5. Mili FD, Teng Y, Shiraishi RW, Yu JP, Bock N, Drammeh B, et al. New HIV infections from blood transfusions averted in 28 countries supported by PEPFAR blood safety programs, 2004 - 2015. Transfusion 2021;61(3):851 – 61. http://dx.doi.org/10.1111/trf.16256.
6. Murray CJL, Ortblad KF, Guinovart C, Lim SS, Wolock TM, Roberts DA, et al. Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384(9947):1005 – 70. http://dx.doi.org/10.1016/S0140-6736(14)60844-8.
7. de Siqueira-Filha NT, Legood R, Cavalcanti A, Santos AC. Cost of tuberculosis diagnosis and treatment in patients with HIV: a systematic literature review. Value Health 2018;21(4):482 – 90. http://dx.doi.org/10.1016/j.jval.2017.09.003.
8. Stover J, Bollinger L, Izazola JA, Loures L, DeLay P, Ghys PD, et al. What is required to end the AIDS epidemic as a public health threat by 2030? The cost and impact of the fast-track approach. PLoS One 2016;11(5):e0154893. http://dx.doi.org/10.1371/journal.pone.0154893.
9. Athanasakis K, Naoum V, Naoum P, Nomikos N, Theodoratou D, Kyriopoulos J. A 10-year economic analysis of HIV management in Greece: evidence of efficient resource allocation. Curr Med Res Opin 2022;38(2):265 – 71. http://dx.doi.org/10.1080/03007995.2021.2015158.
10. Nosyk B, Zang X, Krebs E, Enns B, Min JE, Behrends CN, et al. Ending the HIV epidemic in the USA: an economic modelling study in six cities. Lancet HIV 2020;7(7):e491 – 503. http://dx.doi.org/10.1016/S2352-3018(20)30033-3.
11. Bozzani FM, Vassall A, Gomez GB. Building resource constraints and feasibility considerations in mathematical models for infectious disease: a systematic literature review. Epidemics 2021;35:100450. http://dx.doi.org/10.1016/j.epidem.2021.100450.
12. Kelly SL, Martin-Hughes R, Stuart RM, Yap XF, Kedziora DJ, Grantham KL, et al. The global Optima HIV allocative efficiency model: targeting resources in efforts to end AIDS. Lancet HIV 2018;5(4):e190 – 8. http://dx.doi.org/10.1016/S2352-3018(18)30024-9.
13. Kedziora DJ, Stuart RM, Pearson J, Latypov A, Dierst-Davies R, Duda M, et al. Optimal allocation of HIV resources among geographical regions. BMC Public Health 2019;19(1):1509. http://dx.doi.org/10.1186/s12889-019-7681-5.
14. Gromov D, Bulla I, Silvia Serea O, Romero-Severson EO. Numerical optimal control for HIV prevention with dynamic budget allocation. Math Med Biol 2018;35(4):469 – 91. http://dx.doi.org/10.1093/imammb/dqx015.

SUPPLEMENTARY TABLE S1. GDP deflator of 6 cities from 2015–2019.

City	Year	Gross regional product (Current year price, Unit: 100 million CNY)	Regional GDP index	Regional GDP deflator
S	2015	5,440.60	100.00	1.23
	2016	5,857.80	106.80	1.24
	2017	6,460.90	114.49	1.24
	2018	6,082.60	122.96	1.12
	2019	5,809.90	131.20	1.00
Y	2015	6,086.49	100.00	1.02
	2016	6,455.84	107.70	1.01
	2017	6,762.00	114.59	1.01
	2018	7,184.43	121.81	0.99
	2019	7,653.45	128.51	1.00
N	2015	8,295.35	100.00	0.91
	2016	8,972.83	107.20	0.92
	2017	10,146.55	115.67	0.92
	2018	11,193.14	123.77	1.00
	2019	11,985.12	132.18	1.00
Z	2015	3,088.47	100.00	0.97
	2016	3,435.73	109.30	0.99
	2017	3,847.79	117.17	0.99
	2018	3,847.79	120.80	1.00
	2019	4,077.32	127.81	1.00
F	2015	8,107.60	100.00	1.00
	2016	8,756.31	107.91	1.00
	2017	9,382.16	116.51	1.00
	2018	9,976.72	123.92	0.99
	2019	10,751.02	132.47	1.00
W	2015	8,681.37	100.00	0.97
	2016	9,340.16	107.50	0.97
	2017	10,313.07	115.46	0.97
	2018	11,202.98	124.00	1.01
	2019	11,803.32	132.18	1.00

Note: Data source: Statistical Yearbook of 6 cities; Shijiazhuang statistical yearbook in 2020 (*1*); Yantai statistical yearbook in 2020 (*2*); Ningbo statistical yearbook in 2020 (*3*); Zhenjiang statistical yearbook in 2020 (*4*); Foshan statistical yearbook in 2020 (*5*); and Wuxi statistical yearbook in 2020 (*6*).

Abbreviations: GDP=Gross domestic product; CNY=Chinese yuan.

REFERENCES

1. Shijiazhuang Bureau of Statistics, Shijiazhuang Investigation Team of National Bureau of Statistics. Shijiazhuang statistical yearbook in 2020. Beijing: China Statistics Press. 2021. http://tjj.sjz.gov.cn/col/1584345186126/2021/07/21/1626855580453.html. [2021-6-26]. (In Chinese).
2. Yantai Bureau of Statistics. Yantai statistical yearbook in 2020. Yantai: Yantai Bureau of Statistics. 2020. http://tjj.yantai.gov.cn/art/2021/1/11/art_118_2876126.html. [2021-6-26]. (In Chinese).
3. Ningbo Bureau of Statistics, Ningbo Survey Team of National Bureau of Statistics. Ningbo statistical yearbook in 2020. Beijing: China Statistics Press. 2020. http://vod.ningbo.gov.cn:88/nbtjj/tjnj/2020nbnj/indexch.htm. [2021-6-26]. (In Chinese).
4. Zhenjiang Bureau of Statistics, Zhenjiang Survey Team of National Bureau of Statistics. Zhenjiang statistical yearbook in 2020. Beijing: China Statistics Press. 2020. http://find.nlc.cn/search/showDocDetails?docId=-8904574365069863899&dataSource=ucs01&query=%E9%95%87%E6%B1%9F%E7%BB%9F%E8%AE%A1%E5%B9%B4%E9%89%B42020. [2021-6-26]. (In Chinese).
5. Foshan Bureau of Statistics. Foshan statistical yearbook in 2020. http://www.foshan.gov.cn/attachment/0/153/153028/4654170.zip. [2021-6-26]. (In Chinese).
6. Wuxi Bureau of Statistics, Wuxi Survey Team of National Bureau of Statistics. Wuxi statistical yearbook in 2020. Beijing: China Statistics Press. 2020. http://find.nlc.cn/search/showDocDetails?docId=3013650469888556520&dataSource=ucs01&query=%E6%97%A0%E9%94%A1%E7%BB%9F%E8%AE%A1%E5%B9%B4%E9%89%B42020. [2021-6-26]. (In Chinese).

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