

Original Article

An Alarming High Proportion of HIV-1 Isolates Carrying Mutations Corresponding to Resistance to Antiretroviral Drugs among HIV-Positive High-Risk Groups in Central Vietnam: a Substudy of the National Sentinel Survey

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SUMMARY: We studied the prevalence of HIV drug resistance among high-risk groups such as injecting drug users (IDUs), female sex workers (FSWs), and men having sex with men (MSM) in central Vietnam. We used HIV-positive blood samples from 2012–2013 sentinel surveillance surveys. Study subjects were screened for HIV infection by standardized screening assays, and the HIV-positive samples were further tested for HIV viral load and drug-resistance mutations (DRMs) by in-house assays. DRMs were identified using the Stanford University online sequence analysis tool. Their risk behaviors were also investigated. During the study period, 6,016 (high-risk) subjects were screened, and 97 tested positive for HIV infection (IDUs: $n = 63$, 3.0%; FSWs: $n = 24$, 0.9%; and MSM: $n = 10$, 1.0%). Ninety-two of the 97 samples (45 from 2012 and 47 from 2013) were available for further testing. HIV RNA was detected in 56 (60.9%) of the 92 samples, and drug resistance genotyping was successfully performed on 40 (71.4%) samples. All these isolates were subtype CRF01_AE, except for 1 (2.5%) IDU whose HIV belongs to subtype B. Thirteen individuals (32.5%) were carrying HIV with at least 1 DRM: 9 IDUs, 1 FSW, and 3 MSM. Thus, HIV seroprevalence among high-risk individuals in central Vietnam is low, but a high proportion of drug resistant HIV-1 isolates is observed in the high-risk group.

INTRODUCTION

There were nearly 37 million people living with HIV/AIDS, 2.1 million new HIV infections, and 1.1 million deaths due to AIDS-related diseases in 2015 worldwide. Sub-Saharan Africa was the most affected, with 25.8 million people living with HIV/AIDS, followed by Asia and the Pacific region, where 5 million people living with HIV/AIDS (1). In Vietnam, there were approximately 254,000 people living with HIV at the end of 2013, and 14,000 new infections were reported annually (2). In response to the global HIV epidemic, World Health Organization (WHO) has recommended introduction of antiretroviral therapy (ART) as a public health approach. ART has been widely implemented even in resource-limited countries, and by mid-2016, 18.2 million people living with HIV were receiving ART globally (1).

ART prolongs the life expectancy of HIV patients, however, the development of drug resistance is a major problem. A rapid rollout of ART with a relatively limited drug selection can lead to HIV drug resistance develop-

ment (3). Drug resistance development and transmission of drug-resistant HIV is a major problem in HIV care (4,5). Drug resistance prior to ART is associated with a higher rate of treatment failure. Therefore, evaluation of pretreatment HIV drug resistance is important and should guide a treatment program (6). Nevertheless, this strategy may be practical only in developed countries. As for developing countries, WHO recommends surveillance of baseline drug resistance only on a population level to guide programmatic strategies (7,8).

Developing countries with limited resources, e.g., Vietnam, have a higher burden of HIV. The first case of HIV in Vietnam was reported in 1990 in Ho Chi Minh (9), and then the infection spread throughout the country. HIV-1 has spread to 98% of the districts in Vietnam (10). Surveillance data indicated that there were 218,204 people living with HIV-1 in Vietnam as of March 2014 (10). In Vietnam, ART for AIDS patients began in the 2000s, and by the end of 2013, there were 82,687 patients having access to ART, including 4,249 children. However, ART introduction in Vietnam has led to reporting of 2.9% prevalence of antiretroviral drug-resistant HIV among ART-naïve populations after 12 months of treatment (10). Nevertheless, drug resistance surveillance has not been implemented into HIV sentinel surveillance in Vietnam.

There is limited information on transmitted drug resistance in central Vietnam. Thus, we conducted this study to clarify the current prevalence of HIV, drug resistance, and risk behavior among HIV risk groups in central Vietnam.

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MATERIALS AND METHODS

Study population and data collection: The Vietnamese government has conducted annual nationwide HIV sentinel surveillance since 2003. Seven provinces, Quang Tri, Thua Thien Hue, Da Nang, Binh Dinh, Khanh Hoa, Ninh Thuan, and Binh Thuan have been included in the sentinel surveillance in central Vietnam though the number of included provinces has varied depending on the prevalence of high-risk groups in the provinces in accordance with the Ministry of Health guidelines. The present study was conducted as a sub-analysis of HIV-1 sentinel surveys between June and September in 2012 and in 2013.

Sentinel surveillance inclusion criteria: The study subjects had to be aged 16 years or older and to have the capacity for their own civil action. The injecting drug user (IDU) group was defined as men who injected drugs at least once within the last 1 month before the time of sample collection. The female sex worker (FSW) group was defined as women selling sex with vaginal or anal contact, in the locality of the province, at least once within 1 month before the time of sample collection. The men having sex with men (MSM) group was defined as men who had sex with other men through anal contact in the past 12 months.

Recruitment: Peer educators for high-risk groups in each province approached the individuals with high-risk behavior to participate in the sentinel surveillance. Approximately 150 to 300 subjects for each high-risk group were recruited from each province. Recruitment continued until the sample size reached the target in each province. The individuals were enrolled anonymously. Basic risk behaviors were confirmed using standardized questionnaire forms.

Laboratory methods: HIV screening tests: The HIV screenings assays were performed at local provincial AIDS center laboratories. A sample was defined as HIV-1 positive if the sample tested positive in 2 different assays. Three HIV screening kits; ELISA Genscreen HIV1/2 ver. 2 with HIV1 antigen (gp160) and HIV2 (gp36) (Bio-Rad, Hercules, CA, USA), Murex HIV Ag/Ab Combination Kit (Diasorin, Dartford, UK), Determine HIV1/2 produced with HIV1 antigen (gp41), HIV2 (gp36) (Alere, Waltham, MA, USA) were available at the provincial AIDS centers and used in this study. The test-positive samples were sent to Pasteur Nha Trang for further confirmation testing.

HIV-1 viral load (VL): Viral RNA was extracted from 500 µl of plasma samples using the QIAamp Viral RNA Kit (Qiagen, Hilden, Germany). HIV-1 viral load was determined by an in-house real-time reverse-transcriptase polymerase chain reaction (RT-PCR) assay using primers and probes previously published by Drosten et al. (11). The assay involves in-house, plasmid-derived HIV-1 RNA standards, brome mosaic virus RNA (1 pg/sample) as an internal quality control, the Superscript III Platinum Taq One Step RT-PCR Kit (Invitrogen, Carlsbad, CA, USA), and the ABI 7500 FAST real-time platform (Applied Biosystems, Foster city, CA, USA).

HIV drug resistance genotyping: Samples with a detectable VL were further examined for the presence of a drug resistance mutation (DRM) by in-house drug

resistance screening assays, as previously described (NIID protocol) (12). Codons 4–98 of the protease and codons 38–248 of the reverse transcriptase (RT) regions of the HIV-1 *pol* gene were analyzed for the presence of DRMs using the Stanford University online sequence analysis tool <http://hivdb.stanford.edu/pages/algs/sierra_sequence.html>.

Phylogenetic analysis: The protease and RT sequences from each sample were concatenated to form 1 sequence of 917 nucleotides in length. Reference sequences of interest were retrieved from GenBank and Los Alamos databases. Nucleotide sequences were aligned and edited by the ClustalW algorithm implemented in the MEGA software ver. 6.0.6. (13). For the selection of a best-fit nucleotide substitution model, KAKUSAN4 <<http://www.fifthdimension.jp/products/kakusan/>> was utilized, and the model with the lowest Bayesian Information Criterion value was selected as the best-fit nucleotide substitution model (14). Phylogenetic analysis was carried out by the maximum likelihood (ML) method with the general time-reversible model with a gamma distribution and invariant sites. The reliability of the ML tree topology was estimated by the bootstrap method with 1,000 replications by means of MEGA software ver. 6.0.6. (13), and bootstrap values greater than 70 were assumed to denote statistical significance. Phylogenetic analysis was conducted using reference sequences from the GenBank and Los Alamos databases.

GenBank sequence information: The nucleotide sequences of the concatenated HIV protease and RT genes obtained in the present study were deposited in the GenBank database under the following accession numbers: KY766269–KY766308.

Statistical analysis: Data were entered into the Epi-Data 3.1 software (Odense, Denmark), and all statistical analyses were carried out in Stata ver. 11.2 (StataCorp, College Station, TX, USA). Descriptive data analyses were performed on risk behavior among the high-risk groups. The chi-squared test was applied to analyze a possible association between categorical variables.

Ethics statement: The study protocol was approved by Pasteur Institute of Nha Trang ethical review board and the Ministry of Health, Vietnam. Informed consent was obtained from the study subjects. The subjects' participation in the survey was completely voluntary, to ensure the respect, dignity, and freedom. The study subjects were assigned study ID numbers, and personal information was not collected. The participants were informed of the study and given an explanation of the risks, and benefits of participation in the study. Each subject's anonymity was strictly protected.

RESULTS

The sentinel surveillance sites in central Vietnam are shown in Fig. 1. A total of 1,100 and 1,000 IDUs, 1,400 and 1,506 FSWs, and 560 and 450 MSM were recruited for the sentinel surveillance in 2012 and 2013, respectively. After testing for HIV antigens and antibodies, 63 HIV-infected IDUs were recruited from 5 provinces, 24 HIV-infected FSWs were recruited from 6 provinces, and 10 HIV-infected MSM were recruited from 3 provinces for this substudy. The two-year sentinel surveillance revealed that HIV-1 positivity rate among IDUs

in central Vietnam was 3.1% in 2012 and 2.9% in 2013, and Khanh Hoa province showed the highest HIV prevalence among the high-risk groups (Table 1).

In total, 2,100 IDUs, 2,762 FSWs, and 1,009 MSM filled out the questionnaire. Their age, marital status,



Fig. 1. Sentinel surveillance sites in central Vietnam. Eleven provinces in central Vietnam are shown. Seven sentinel surveillance sites in central Vietnam are shown in grey.

and risk behavior are summarized in Table 2. In terms of risk behaviors, one third (37.0%) of IDUs did not use a clean syringe during their last intravenous drug use. IDUs ($n = 1,794$; 85.4%) have had sex before, but 47.7% ($n = 856$) did not use a condom during their last intercourse. IDUs ($n = 744$; 41.5%) have had sex with a sex worker before, and 377 answered questions related to condom usage. The responses revealed that 6.9% ($n = 26$) never and 15.1% ($n = 57$) only occasionally used a condom for sex with a sex worker in the last 1 month.

FSWs (99.2%) used a condom for sex during the last 1 month: all the time (70.9%) or most of the time (23.8%). During the last intercourse with a client, 92.7% of the clients used a condom.

Only 53.6% of MSM used a condom in the last one month while having sex with their male partner: all the time (37.8%) or most of the time (15.9%). Two point one percent ($n = 21$) of MSM have used intravenous drugs before, of whom 9.5% did not use a clean syringe during their last drug use (Table 2).

Viral load, subtyping, and drug resistance genotyping: HIV-1 VL testing: This testing was performed on 92 available (blood) samples (58 IDUs, 24 FSWs, and 10 MSM). Table 3 shows a summary of the results. VL above the detection limit was observed in 56 (60.9%) out of the HIV-infected individuals, namely, 30/58 (51.7%) IDUs, 16/24 (66.7%) FSWs, and 10/10 (100%) MSM. The median VL was 28,000 copies/ml. Twenty-one individuals (21.6%), i.e., 8 from 2012 and 13 from 2013, were receiving ART, which included 19 (30.2%) IDUs and 2 (8.3%) FSWs. Among those receiving ART ($n = 21$), 7 (33.3%) showed VL above the detection limit. Fourteen individuals from the group where the viral RNA was not detected ($n = 36$) were receiving ART. Individuals with the viral load below the detection limit were more likely to be treated with ART than individuals with detectable HIV viremia: 38.9% (14/36) vs. 12.5% (7/56), respectively (Pearson's $\chi^2 = 8.6625$, $p = 0.003$).

Table 1. HIV-1 seroprevalence among high-risk groups in central Vietnam in 2012 and 2013¹⁾

Year	Province	Quang Tri	TT. Hue	Da Nang	Binh Dinh	Khanh Hoa	Ninh Thuan	Binh Thuan	Total
IDUs									
2012	tested	300	150	300	ND	200	ND	150	1,100
	-positive (%)	7 (2.3)	5 (3.3)	7 (2.3)	ND	13 (6.5)	ND	2 (1.3)	34 (3.1)
2013	tested	250	150	300	ND	150	ND	150	1,000
	-positive (%)	5 (2.0)	5 (3.3)	7 (2.3)	ND	10 (6.7)	ND	2 (1.3)	29 (2.9)
FSWs									
2012	tested	300	300	300	150	200	ND	150	1,400
	-positive (%)	1 (0.3)	3 (1.0)	0 (0.0)	0 (0.0)	4 (2.0)	ND	3 (2.0)	11 (0.8)
2013	tested	250	300	300	150	200	144	162	1,506
	-positive (%)	0 (0.0)	3 (1.0)	2 (0.7)	0 (0.0)	4 (2.0)	0 (0.0)	4 (2.5)	13 (0.9)
MSM									
2012	tested	ND	ND	260	ND	300	ND	ND	560
	-positive (%)	ND	ND	1 (0.4)	ND	4 (1.3)	ND	ND	5 (0.9)
2013	tested	ND	150	150	ND	150	ND	ND	450
	-positive (%)	ND	1 (0.7)	1 (0.7)	0 (0.0)	3 (2.0)	ND	ND	5 (1.1)

¹⁾ Data are presented as number (%).

IDU, injective drug user; ND, not determined; FSW, female sex worker; MSM, men having sex with men.

Phylogenetic analysis: RT-PCR assays of the protease and RT genes were performed on the virus-positive samples ($n = 56$), and in 71.4% of samples ($n = 40$; 19 IDUs, 12 FSWs, and 9 MSM), the amplifications were successful. Phylogenetic analysis of the amplified protease and RT gene sequences indicated that all these belong to subtype CRF01_AE except for 1 subtype B (Fig. 2). Although some pairs of HIV isolates showed high sequence similarity, further background information and

analysis will be needed to demonstrate the specific cluster of transmission in these individuals. The strains from central Vietnam were distributed in groups similar to those for isolates from northern and southern Vietnam.

HIV-1 DRMs: These mutations were found in 13 (32.5%; 9 IDUs, 1 FSW, and 3 MSM) of the successfully amplified samples of protease gene (Table 4). Nine (47.4%) out of the 19 tested samples from IDUs contained DRMs. This proportion was high even among

Table 2. Characteristics and risk behaviors of IDUs, FSWs, and MSM recruited for the current subanalysis¹⁾

Characteristic/risk behavior	IDU ($n = 2,100$)	FSW ($n = 2,762$)	MSM ($n = 1,009$)	
Age (yr)	median (IQR)	27 (23–24)	29 (24–37)	23 (20–27)
	< 20	216 (10.3)	191 (6.9)	239 (23.7)
	20–29	1,100 (52.4)	1,287 (46.6)	582 (57.7)
	≥ 30	782 (37.2)	1,279 (46.3)	187 (18.5)
	do not remember	2 (0.1)	5 (0.2)	1 (0.1)
Marital status	single	1,222 (58.2)	1,070 (38.7)	903 (89.5)
	married/fix partner	696 (33.1)	638 (23.1)	66 (6.5)
	divorce/separated	181 (8.6)	1,054 (38.2)	33 (3.3)
	not answered	1 (0.1)	0 (0.0)	7 (0.7)
HIV status	screening-positive	63 (3.0)	24 (0.9)	10 (1.0)
	genotyping completed	19	12	9
	DRM detected	9 (47.4)	1 (8.3)	3 (33.3)
	DRM with ART naïve	8 (42.1)	1 (8.3)	3 (33.3)
Have you ever injected drugs?	yes	2,100 (100.0)	22 (0.8)	21 (2.1)
	no	0 (0.0)	2,740 (99.2)	988 (97.9)
	Total	2,100	2,762	1,009
On the last time you injected, did you use a new/clean syringe and needle?	yes	1,323 (63.0)	N/A	16 (76.2)
	no	777 (37.0)	N/A	2 (9.5)
	not answered	0 (0.0)	N/A	3 (14.3)
	Total	2,100	(22)	21
In the last sex, did you and your client/partner use a condom?	yes	907 (50.6)	2,561 (92.7)	541 (53.6)
	no	856 (47.7)	186 (6.7)	243 (24.1)
	not answered	31 (1.7)	15 (0.5)	225 (22.3)
	Total	1,794	2,762	1,009
During the last 1 month, how often have you used condom when you had sex?		sex with FSW	sex with any client	sex with male partner
	all the time	202 (53.6)	1,958 (70.9)	381 (37.8)
	most of the time	92 (24.4)	657 (23.8)	160 (15.9)
	occasionally	57 (15.1)	125 (4.5)	109 (10.8)
	never	26 (6.9)	22 (0.8)	29 (2.9)
	not answered	0 (0.0)	0 (0.0)	330 (32.7)
Total	377	2,762	1,009	

¹⁾ Data are presented as number (%) unless otherwise indicated.

IDU, injective drug user; FSW, female sex worker; MSM, men having sex with men, IQR, interquartile range; N/A, not applicable.

Table 3. Proportions of anti-retroviral drug resistant HIV among high-risk group

	IDU	FSW	MSM	Total
HIV-infected individuals	63	24	10	97
on ART	19 (30.2) ¹⁾	2 (8.3)	0 (0.0)	21 (21.6)
Tested for VL	58	24	10	92
HIV detected	30 (51.7)	16 (66.7)	10 (100.0)	56 (60.9)
Tested for DR genotyping ²⁾	19	12	9	40
DR mutations detected	9 (47.4)	1 (8.3)	3 (33.3)	13 (32.5)
ART naïve with DR mutations	8 (42.1)	1 (8.3)	3 (33.3)	12 (30.0)

ART, antiretroviral therapy; VL, viral load; DR, drug-resistance.

¹⁾ Data are presented as number (%).

²⁾ A single protease-RT fragment was amplified in 2 samples in 2012. Protease and RT fragments were separately amplified and aligned to construct on fragment and analyzed for the rest of the samples.

Drug-Resistant HIV in Central Vietnam

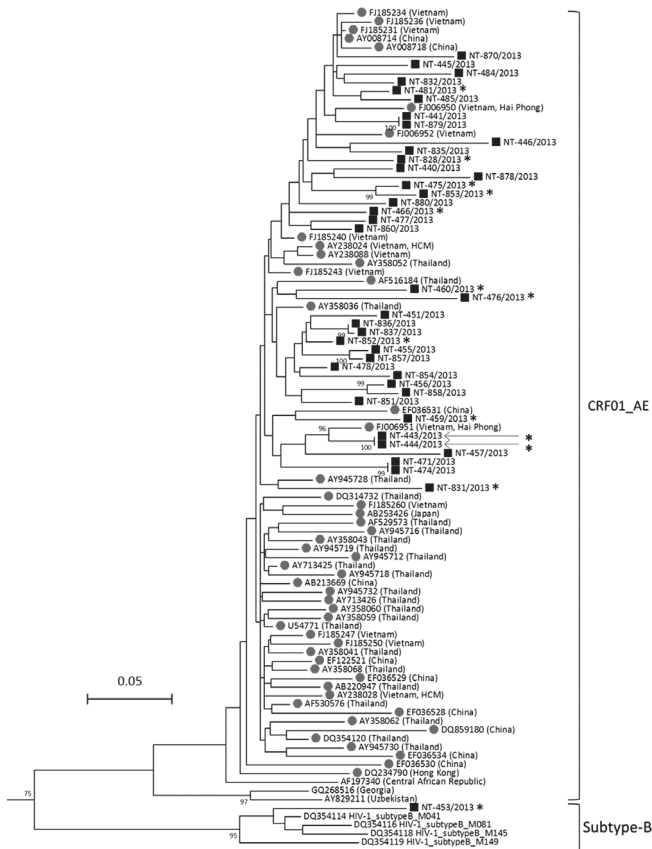


Fig. 2. Phylogenetic analysis of HIV-1 positive IDUs, FSWs, and MSM in central Vietnam. Phylogenetic tree analysis was based on 1,095 bp *pol* gene (positions 2253 to 3347, protease-reverse transcriptase regions) sequence, including 287 bases from the *pol* gene-protease region and 630 bases from the *pol* gene-reverse transcriptase region. ■ HIV-1 positive samples in central Vietnam. ● Reference strains from Los Alamos HIV database. Bootstrap values are shown. * HIV-1 positive samples with drug resistant mutations.

ART-naïve IDUs (42.1%). The viremia prevalence among IDUs was also high (26.0%). A mutation was found in 1 out of 12 FSWs (8.3%) and in 3 out of 9 MSM (33.3%), respectively.

Four of the individuals had protease inhibitor-associated mutations such as L10I/V, V11I, M46I, and A71T, and 11 of them had nucleotide reverse transcriptase inhibitor (NRTI) and non-nucleotide reverse transcriptase inhibitor (NNRTI) resistance mutations. Six individuals had 1 NNRTI resistance mutation each (2 had K103N, 2 had V106I, and 2 had V179D), while 4 of them had multiple NRTI resistance mutations (D67E/T, T69N, K70R, M184V, T215Y/F, and K219E/Q) and NNRTI resistance mutations (L100I, K101E, K103N, V106I, Y181C, and M230L). The one individual infected with subtype B HIV had multiple NRTI and NNRTI resistance mutations.

We found 3 pairs of samples carrying a DRM with high bootstrap values (Fig. 2). Although we do not have any background information that can link these pairs of samples, there is a possibility that they have a common source of infection or one may have infected the other.

DISCUSSION

This is the first study to describe the HIV prevalence and antiretroviral drug resistance among high-risk groups in central Vietnam. We observed overall decreasing prevalence of HIV. On the other hand, an alarmingly high prevalence rate of drug-resistant HIV isolates and high-risk behaviors among HIV-infected high-risk individuals were observed.

The sentinel surveillance on HIV seroprevalence among IDUs and FSWs in central Vietnam started in 2003. The yearly HIV sentinel surveillance indicated a steady decline of HIV-1 prevalence among IDUs and FSWs since 2003. The HIV rates among the IDUs and FSWs decreased from 19.0% and 1.4% to 2.9% and

Table 4. Characteristics of 13 DRM cases

ID	Year	Province	Risk group	Duration of risk (yr)	Times of risk behavior ¹⁾	Frequency of having protective measures ²⁾	Age	on ART	Subtype	Antiretroviral DR mutation		
										PI	NRTI	NNRTI
13M00459	2012	Binh Thuan	IDU	3	30	always	30	No	CRF01_AE	L10I		
13M00481	2012	Da Nang	IDU	3	30	always	26	No	CRF01_AE		D67E; T69N; K70R	
13M00460	2012	Khanh Hoa	IDU	14	48	always	36	Yes	CRF01_AE		M184V; T215Y	K101E; Y181C
13M00466	2012	Khanh Hoa	IDU	14	3	always	29	No	CRF01_AE			K103N
13M00443	2012	Quang Tri	IDU	2	12	N/A	31	No	CRF01_AE			V106I
13M00444	2012	Quang Tri	IDU	5	25	N/A	26	No	CRF01_AE			V106I
13M00453	2012	TT. Hue	IDU	2	10	N/A	20	No	B		D67T; T69N; K70R; M184V; K219E	L100I; K103N; V179D
13M00475	2012	Khanh Hoa	MSM	20	(6)	<u>sometimes</u>	38	No	CRF01_AE	L10V		V179D
13M00476	2012	Khanh Hoa	MSM	N/A	(3)	<u>rarely</u>	31	No	CRF01_AE		D67E; T69N; K70R; M184V; T215F; K219Q	V106I; Y181C; M230L
13M00853	2013	Khanh Hoa	MSM	23	(5)	<u>sometimes</u>	39	No	CRF01_AE			V179D
13M00852	2013	Khanh Hoa	FSW	5	(60)	<u>sometimes</u>	33	No	CRF01_AE			K103N
13M00828	2013	Da Nang	IDU	4	40	N/A	27	No	CRF01_AE	L10V, V11I	T69N	
13M00831	2013	Da Nang	IDU	3	90	N/A	21	No	CRF01_AE	M46I, A71T		

ART, antiretroviral therapy; PI, protease inhibitor; NRTI, nucleotide reverse transcriptase inhibitor; NNRTI, non-nucleotide reverse transcriptase inhibitor. Notably description are underlined.

¹⁾ No. of injecting drug use in the last 1 month is shown if IDU; No. of sex is shown in bracket if MSM or FSW.

²⁾ Frequency of using clean syringe/needle is shown if IDU; frequency of having condom is shown in bracket if MSM or FSW.

0.9%, respectively, between 2003 and 2013 (15). This achievement is due to the public health intervention by the government and international nongovernmental organizations in central Vietnam. On the other hand, the sentinel surveillance for MSM started recently in 2011, in a limited population of central Vietnam and showed a slight increase in the prevalence: from 0.5% in 2011 to 1.1% in 2013. Nonetheless, this prevalence is still lower than the rate among MSM in the whole Vietnam, which was 4.0% in 2011 and 3.7% in 2013. Certain provinces in central Vietnam such as Khanh Hoa have higher HIV prevalence among MSM as compared to other provinces, and the prevalence is increasing since 2011 (from 1.0% in 2011 to 2.0% in 2013) (15). The study area is a rapidly developing tourist region visited by many domestic and international travelers. Therefore, it is necessary to closely monitor the HIV situation in these provinces and further implement public health and preventive measures against HIV.

Even though a public health campaign has been implemented to promote condom use, especially among the high-risk groups, the condom use rate is still low especially in IDU and MSM groups. In addition, the use of new syringes for injectable drugs among IDUs was also found to be low, indicating that risky behavior remains common in HIV high-risk groups, especially among IDUs in central Vietnam.

We observed that the HIV drug resistance level was high among HIV-infected high-risk groups in central Vietnam compared to other parts of the country, particularly among IDUs which showed the highest drug resistant rate (44.4%). We also found that one of IDUs with drug resistant HIV from Thua Thien Hue province, a popular tourist destination, had type B clade. This resistant strain may have been imported by a tourist.

The prevalence of antiretroviral drug-resistant HIV may be differ by geographic region and could have increased with duration of treatment. The regions with the biggest increase in the rate of DRMs per year is East Africa (29%) followed by South Africa (14%). Latin America did not show a significant change in the DRM rate after introduction of highly active ART. In Asia, Vietnam has the highest rate of DRMs (4.5%) in the HIV-positive population in comparison with 0.5% in Thailand, 2.6% in China, and 2.7% in India (16). Our results suggest that the high prevalence of drug resistance may be due to a higher proportion of IDUs in the HIV-positive population in Vietnam. During the 2008–2009 period, some studies showed that there were 6.2% and 5.4% of drug-resistant HIV isolates among HIV-infected patients in north and south Vietnam, respectively (17,18). The DRM rate in the ART naïve HIV-positive population ranges from 2.6% to 5.3% in countries such as China, India, Thailand, Hong Kong, Philippines, and Malaysia. Studies in Vietnam have shown an HIV drug resistance rate of around 3.5% to 8.2% (12,17–20). Higher DRM rates, 9.2% and 14.2%, were observed among ART-naïve MSM in Thailand and China, respectively (21,22). Several reports indicate that MSM and IDU groups have higher rates of DRMs than other groups do (20,22,23).

MSM, IDUs, and FSWs are high-risk groups in terms of HIV infection; at the same time, they are at the high-risk of transmission of drug-resistant HIV. Considering

this fact and the report from other parts of Vietnam (6.6%) (17,18,24), our results on the DRM rate in the IDU population (47.4%) and in the MSM population (33.3%) are still alarmingly high.

The limitation of our study is that some samples were not available for testing, and VL testing yielded negative results in a considerable proportion of the samples. Only 60.9% showed a detectable VL, and several samples from ART-naïve subjects also tested negative. One possible reason may be poor quality of the samples due to the inadequate sample storage conditions at the district public health centers. Alternatively, there may be sequence polymorphism at the primer-binding sites that were used for VL testing, or the VL may have been truly low. Nevertheless, the drug resistance rate in the IDU group was high even when we calculated the rate of drug-resistant HIV rate among all HIV-positive subjects.

Acquired and transmitted HIV-1 drug resistance are public health concerns, and persons carrying HIV with a DRM are at a higher risk of virologic failure. Therefore, monitoring of risk behavior and testing for drug resistance among high-risk groups are important. We observed overall decreasing prevalence of HIV among high-risk groups in this 2-year study. However, further health education about transmission of drug-resistant HIV and intervention activities such as regular condom and syringe distribution by peer educators to high-risk groups may further lower the prevalence of drug-resistant HIV at the high-risk population. Incorporation of routine HIV drug-resistance testing at the population level should also be considered for accurate monitoring of the HIV drug resistance among treatment-naïve high-risk groups in Vietnam.

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Conflict of interest None to declare.

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Drug-Resistant HIV in Central Vietnam

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