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ORIGINAL PAPER

A Comparison Between Respondent-Driven Sampling and Time-Location Sampling Among Men Who Have Sex with Men in Shenzhen, China

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Abstract Men who have sex with men (MSM) are a key population for HIV control and prevention in China. It is difficult to acquire representative samples of this hidden population. Respondent-driven sampling (RDS), based on peer referral, and time-location sampling (TLS) based on random selection of venue-day-time periods, are among the most commonly used sampling methods. However, differences in HIV-related characteristics of MSM recruited by these two methods have not been fully evaluated. We compared sociodemographics, risk behaviors, utilization of HIV-related intervention services, and HIV/syphilis infection rates between samples of 621 RDS MSM and 533 TLS MSM in Shenzhen, China in 2010. We found that the HIV prevalence was comparable in RDS and TLS MSM. TLS recruited larger proportions of more marginalized MSM than RDS: MSM recruited by TLS were older, less educated and more likely to be migrants (without Shenzhen *hukou* registration), to be non-gay identified and to engage in risky sexual behaviors. On the other hand, MSM recruited by TLS were more likely to have been covered by HIV-related intervention services. To conclude, in Shenzhen, TLS is more effective to reach the marginalized population of MSM. But because TLS can only reach MSM who physically attend venues and HIV-related intervention services are already commonly available at gay venues in Shenzhen, RDS is more informative for allocating prevention efforts than TLS. Furthermore, researchers and public health authorities should take into account the different sample compositions of RDS and TLS and apply sampling methods consistently when evaluating trends over time.

Keywords Respondent-driven sampling · Time-location sampling · Men who have sex with men · Sexual orientation · China

Introduction

According to the national surveillance report, men who have sex with men (MSM) comprised approximately 30 % of the new HIV cases in China and the prevalence of HIV among them has increased from about 1 % in 2005 to 5 % in 2011 (WHO, UNAIDS, & Ministry of Health, 2011). Due to the traditional cultures and values, bisexual behavior is very common among Chinese MSM. It was estimated that 50–70 % of MSM have had sex with females in their lifetime (Chow, Wilson, & Zhang, 2011). There is much concern that MSM will act as a key driver and act as bridge of the HIV epidemic to the general heterosexual population. To track the epidemic and to plan effective control measures, the Chinese government has called for detailed studies of the profiles of sociodemographics and behaviors, and risk factors of HIV infection among MSM. However, such studies have many

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challenges, one of which is acquiring representative population samples.

The gold standard for acquiring representative data is probability-based or population- based sampling. Such a sampling method, however, is not appropriate to sample MSM, because MSM constitute a small proportion (reported to be 2–4 % in China) (Zhang, Li, Shi, Yang, & Zhang, 2002) of the total population. Therefore, population-based surveys need to be very large to include enough MSM for precise estimates. Also, due to stigmatization and discrimination, MSM will be underrecognized in population-based surveys (Kendall et al., 2008). In the absence of a feasible probability-based sampling method, convenience sampling methods, such as internet-based sampling and venue-based sampling, have for many years been used to access MSM. These methods are efficient to recruit participants but lack validity in representation.

In recent years, quasi-probability sampling methods, i.e., respondent-driven sampling (RDS) and time-location sampling (TLS) have been developed to improve representativeness of studied samples. RDS is a long-chain peer referral recruitment method, which allows making population-based inferences through statistical adjustments (Heckathorn, 1997). It starts with identification of potential "seeds," individuals who are then asked to recruit their peers in the study, who in turn further refer their peers, and so on. Each participant is limited to referring two to four peers to avoid bias. For these features, RDS presents to be an effective sampling method with statistical rigor (Kendall et al., 2008; Wei, McFarland, Colfax, Fuqua, & Raymond, 2012). However, it is still an experimental methodology being used for surveillance of high risk groups of HIV/AIDS and debate about the underlying assumptions remains (Rudolph, Fuller, & Latkin, 2013). Through creation of a sampling frame that comprises the universe of venues, days, and time periods where and when the population congregates, TLS systematically samples potential participants at randomly selected venue–day–time periods (Ferreira, de Oliveira, Raymond, Chen, & McFarland, 2008; Karon & Wejnert, 2012; Kendall et al., 2008; Wei et al., 2012). However, a notable limitation of TLS is that it only includes MSM who attend physical venues frequently.

With their own advantages and disadvantages, RDS and TLS stay as two irreplaceable and key sampling methods. In theory, RDS is capable of reaching the marginalized segments of MSM (e.g., MSM who seek partners only via personal social network or internet and who often have disadvantaged socio-economic status) (Feng, Wu, & Detels, 2010; Heckathorn, 1997), whereas TLS can only reach the visible segments of MSM (i.e., MSM who attend physical venues frequently) (Karon & Wejnert, 2012). To date, differences in characteristics of MSM recruited by these two methods have not been fully evaluated in practice. There are only three studies comparing sociodemographic and behavioral characteristics of MSM recruited by RDS and TLS (Kendall et al., 2008; Paz-Bailey et al., 2013; Wei et al., 2012). However, these studies were limited by a small sample size (Wei et al., 2012), comparing data from different years (Kendall et al., 2008), and lack of biological markers (Kendall et al., 2008; Paz-Bailey et al., 2013). Although RDS has been used in a couple of cities to sample Chinese MSM in recent years (Fan et al., 2012; Huan et al., 2013; Tang et al., 2013; Zhang et al., 2011), there is no location where RDS and TLS have been used simultaneously. In our study, we take advantage of a unique opportunity in which RDS and TLS were used simultaneously to sample MSM with relatively large sample sizes ($n = 621$ by RDS and $n = 533$ by TLS) in Shenzhen, China. We hypothesized that the different sampling methodologies of TLS and RDS tap into different segments of MSM, and result in different HIV epidemic estimates. In this paper, we present the empirical evidence of these differences with focus on MSM who have not sold sex to another man in the last 6 months (i.e., MSM who are not money boys).

Method

Participants

Shenzhen is the first special economic zone in Guangdong province, South China. It is a well-developed city, neighboring Hong Kong. Driven by the flourishing economy and openness, numerous people have moved from other places to Shenzhen, from both inner rural areas of China and developed cities like Hong Kong. This "floating population" constitutes the majority of the over 10 million Shenzhen inhabitants (Shenzhen Statistics, 2012), and many MSM are part of this floating population group. It is estimated that there are more than 100,000 MSM and more than 50 MSM venues (Chen, Feng, Tan, Cai, & Zhang, 2008). Sentinel surveillance data revealed that prevalence of HIV infection among MSM increased from 0.2 % in 2002 to over 10 % in 2012 in Shenzhen (Shenzhen CDC, 2013). Currently it is one of the cities in China hit hardest by the HIV epidemic among MSM.

Between May and December 2010, RDS was used to recruit MSM through their social and sexual networks. To begin recruitment chains, we selected 10 initial seed participants that were diversified by age, marital status, and education level. All the seed participants were MSM who reported not having sold sex to another man in the last 6 months. The seeds were selected based on a group discussion with MSM peers from a local non-government organization (NGO), who has collaborated with Shenzhen Center for Disease Control and Prevention (Shenzhen CDC) for nearly 10 years. We gave each seed participant three coded coupons to recruit peers. After informed consent, we then enrolled participants who presented the coupons and who were deemed eligible. In turn, each newly enrolled participant was given three coded coupons to extend the recruitment chain.

Eligibility criteria were: male, at least 18-years old, Chinese national, and having engaged in oral or anal sex with a man in the last 6 months. Male sex workers (also referred to as "money boys" (MBs) who had sold sex to another man in the last 6 months) were excluded from our recruitment, because our previous research has shown that MBs are a significantly different subgroup of MSM (Zhao et al., 2012) and need to be recruited and analyzed separately.

All eligible participants were invited to complete an anonymous computer-assisted questionnaire and come for a confidential HIV and syphilis testing at our interview site. We selected one community clinic run by Shenzhen CDC in cooperation with the local NGO as our interview site. The address, phone number, and office hours of the site were printed on the coupons. In order to avoid duplication of participation, we used a fingerprint system. Upon enrolment, new potential participants were asked to have their fingerprints scanned, which were then checked against our list of previous participants to ensure that they were new to this study. However, the RDS and TLS surveys were independent of each other and each MSM could have participated in both RDS and TLS.

During the same recruiting period (from May to December, 2010) of RDS, we also recruited MSM by TLS. Details about how TLS was applied to sample MSM in Shenzhen were described previously (Zhao et al., 2012). In brief, a random sample of venue-day-time periods (VDTs) was drawn from all possible VDT periods. At the randomly selected VDTs, eligible subjects at venues were invited to participate. At venues where participants were recruited, participants were invited to complete an anonymous computer-assisted questionnaire and a confidential HIV and syphilis testing. Eligibility criteria were the same as with the RDS method. In TLS, we separately recruited MBs and other MSM, and only data on other MSM were used for this study.

For both the RDS and TLS surveys, participants were given the option of only completing the questionnaire if they did not want to be tested, but an incentive was offered only to those who completed the blood testing. In RDS sampling, each individual received 50 RMB (about 6 Euro) for his own participation and a further 10 RMB (about 1.2 Euro) for each participant whom he recruited. In TLS sampling, each individual received 30 RMB (about 4 Euro) for his participation. In both RDS and TLS surveys, there is no participant who completed the questionnaire, but refused testing. Verbal consent was obtained. Participants with negative testing results were informed by internet and participants with positive results were informed by phone and referred to healthcare services for further consultation and treatment. Confidentiality and anonymity were strictly observed. The study was approved by the review board of Shenzhen CDC.

Measures

For both the RDS and the TLS projects, a palmtop computer-assisted questionnaire was used to collect sociodemographic and behavioral information. The questionnaire used in this study were previously verified (Zhao et al., 2012). Trained peer recruiters by Shenzhen CDC explained the study, distributed the questionnaires, and assisted with clarifying questions at the interview site (RDS) or at venues (TLS). It took each participant about 30 min to finish the questionnaire.

Sociodemographic information collected were venues of recruitment, age, education, *hukou* registration (a province/city where a person was registered as a permanent resident), hometown, duration of living in Shenzhen, income, marital status, and sexual orientation. According to 2008 National MSM surveillance (Wang et al., 2012), we defined 4 provinces/cities, i.e., Sichuan, Chongqing, Yunnan, and Guizhou as hometown with high HIV prevalence, because HIV prevalence was above 10 %. The other 27 provinces/cities in China were defined as hometown with low HIV prevalence.

Behavioral information collected were gender of first sex partner, age of first sex experience (not older than 20-years old, or older than 20-years old), type of sex partners (men only, or men and women), number of anal sex partners (no, one, or more than one), any male sex partners from Hong Kong, usual anal sex role (insertive, receptive, or both), any unprotected anal intercourse experience, any condom rupture experience, number of female sex partners (no, one, or more than one), any unprotected anal or vaginal intercourse in the last 6 months. All other background information, such as HIV-related knowledge and condom use knowledge, was described previously (Zhao et al., 2012). All variables were categorical, except for age.

Laboratory Test for HIV and Syphilis

After each questionnaire interview, a blood sample was collected for HIV and syphilis testing. We performed the testing in accordance with standardized laboratory procedures provided by the National Center for Disease Control and Prevention of China. HIV was tested using a rapid test (Determine HIV-1/2/O; Abbott Laboratories, Illinois, USA) and ELISA (Wantai Biotech Inc, Beijing) for screening and Western blot (Genlabs Diagnostics, Singapore) for confirmation. Syphilis was tested using rapid plasma regain method (Rongsheng Biotech Inc, Shanghai, China) for qualitative screening and *Treponema pallidum* particle agglutination assay (Fujirebio Inc, Japan) for confirmation.

Data Analysis

For data collected by RDS, weighting has to be used to adjust for respondents' social network size (i.e., the larger a social network, the greater the likelihood that someone might be recruited by other participants in his social network) and recruitment patterns. We measured the size of the social network of a MSM as the number of other MSM they knew by name, by nickname,

or by face, and who were 18 years or older, lived in Shenzhen and whom they could reach during one month. Individualized weights of HIV (outcome variable) were calculated by RDS Analysis Tool (RDSAT, version 7.1) and then exported to SPSS (version 20.0).

For data collected by TLS, it is necessary to use weights based on the probability that a person is sampled to obtain estimates that refer to the population in the sampling frame (Karon & Wejnert, 2012). We calculated participants' weights according to the following formula: $w = (n_1/N_1)/(n_2/N_2)$, where w is the weight of participants sampled in a venue, n_1 is the total number of eligible subjects at the venue, N_1 is the total number of eligible subjects at all venues in the sampling frame, n_2 is the number of eligible subjects that participated in our survey at the venue, and N_2 is the total number of eligible subjects that participated in our survey at all venues in the sampling frame. Information of weights was also imported into SPSS.

We analyzed the data in three steps. In the first step, we calculated population adjusted point estimates and 95 % confidence intervals (CI) of the frequency of all the variables on sociodemographics and behavior of RDS MSM in RDSAT and TLS MSM in SPSS. In the second step, we compared the adjusted sociodemographic and behavioral information of the RDS MSM and the TLS MSM by proxy-z test. In the final step, we separately conducted weighted logistic regression of HIV risk factors for RDS and TLS data. For both RDS and TLS data, we first performed univariate logistic regression analysis of HIV infection and possible risk factors. The variables attaining $p < .20$ significance in univariate analysis were included in the multivariate regression analysis. Only variables achieving $p < .05$ significance were retained in the final model using backward stepwise elimination. Age was used as a continuous variable in the univariate and multivariate logistic regressions. Categories of age were only used to illustrate trend in prevalence of HIV in different age stratums. Impact of risk factors was expressed as odds ratios (OR) with 95 % confidence interval (CI).

Results

Over an 8-month period, the initial seeds led to recruitment of 611 participants (coupon return rate: 611/1841 = 33 %) who completed both the questionnaire and the serological survey, resulting in a total sample of 621 participants (including the 10 seeds) by RDS. Of the initial 10 seeds, 7 produced at least one wave of recruitment, with the longest chain reaching 22 waves and recruiting 256 participants, the shortest chain recruited only one participant (Table S1). The composition of key sociodemographics (education, marital status, and age) stabilized after wave 3 (Table S2).

During the same sampling period, 851 eligible MSM were identified by TLS and 550 (64.6 %) of them participated in the study. Refusal rates varied with VDTs, ranging from 0 to 76.6 %. Mean refusal rate was lowest in suburb recreational centers (8.4 %) and highest in bars (61.4 %). We excluded 17 questionnaires with missing values on venue attendance data. In total, 533 TLS MSM were included in the final data analysis.

Table 1 compares sociodemographics between RDS and TLS samples. Compared with RDS, TLS MSM were older (mean age: 30 ± 8 vs. 28 ± 7 years, $p < .001$), marginally less educated (18.5 vs. 12.6 % finished junior high school or lower education, $p = .056$), and less likely to hold a Shenzhen *hukou* (6.6 vs. 13.9 %, $p < .001$). There were no significant differences between RDS and TLS samples regarding hometown, income, and marital status. Compared with RDS MSM, TLS MSM were less likely to self-identify as homosexual (57.9 vs. 70.8 %, $p < .001$), and more likely to have both male and female partners (19.2 vs. 11.0 %, $p = .002$), to report both receptive and insertive sex role (42.3 vs. 30.3 %, $p = .002$) and to have more than one anal sex partner (70.0 vs. 52.9 %, $p < .001$), as shown in Table 1. On the other hand, TLS MSM were more likely to have used HIV-related intervention services (80.0 vs. 68.9 %, $p = .001$) and been tested for HIV (48.9 vs. 38.9 %, $p = .008$) in the last year (Table 1). Syphilis infection rate was lower in TLS MSM (14.4 vs. 20.3 %, $p = .055$), but HIV infection rate was slightly higher in TLS MSM, although not significantly so (9.3 vs. 8.4 %, $p = .65$), than that in RDS MSM (Table 1).

Table 2 compares risk factors of HIV infection between RDS and TLS samples. In multivariate logistic regression, HIV infection was associated with from a hometown with high HIV prevalence (adjusted odds ratio, AOR = 2.44, $p = .034$), having multiple anal sex partners (AOR = 2.21, $p = .027$), having STIs history (AOR = 3.85, $p < .001$), not using any HIV-related services (AOR = 3.66, $p < .001$) and self-perceiving moderate (AOR = 2.41, $p = .017$) or high HIV risk (AOR = 4.61, $p = .045$) in RDS MSM. For TLS MSM, HIV infection rate was significantly lower in MSM having a monthly income higher than 3,000 RMB than those having a monthly income of 3,000 RMB or less (AOR = 0.46, $p = .012$). Moreover, HIV infection rate was significantly lower in MSM having both male and female partners than those having male partners only (AOR = 0.35, $p = .043$). Frequency data and results of univariate logistic regression analyses of HIV risk factors in RDS and TLS MSM are shown in Tables S3 and S4.

Discussion

Our study shows that both RDS and TLS resulted in sizable and diverse samples of MSM in Shenzhen, China. The estimates of HIV prevalence in participants recruited by TLS and RDS were comparable. We found that TLS recruited a more marginalized population of MSM than RDS: MSM recruited by TLS were older, less educated and more likely to be migrants (without Shenzhen *hukou* registration), to be non-gay

Table 1 Comparison of HIV/syphilis infection, sociodemographics, behaviors, and use of HIV-related services between 621 men who have sex with men (MSM) by respondent-driven sampling (RDS) and 533 MSM by time-location sampling (TLS) in Shenzhen, China in 2010

Characteristic	RDS crude ($N=621$)		RDS adjusted		TLS crude ($N=533$)		TLS adjusted		*p* value
	n	*n*/*N*(%)	*n*/*N* (%)	(95 % CI)	*n*	*n*/*N*(%)	*n*/*N* (%)	(95 % CI)	
HIV infection (from laboratory test)									.65
No	562	90.5	91.6	(88.3–94.1)	483	90.6	90.7	(88.3–93.2)	
Yes	59	9.5	8.4	(5.9–11.7)	50	9.4	9.3	(6.8–11.7)	
Syphilis infection (from laboratory test)									.055
No	499	80.4	79.7	(74.0–84.6)	458	85.9	85.6	(82.3–88.8)	
Yes	122	19.6	20.3	(15.4–26.0)	75	14.1	14.4	(11.2–17.7)	
Demographics									
Venue of recruitment[a]									
Low-end venues	NA				407	76.4	74.8	(70.6–78.5)	
Dorm-based venues	NA				22	4.1	3.7	(2.1–5.5)	
High-end venues	NA				104	19.5	21.6	(18.0–25.3)	
Age (mean ± SD, continuous, in years)	(28 ± 7)		(28 ± 7)		(30 ± 8)		(30 ± 8)		**<.001**
Education level									
Junior high school or lower	97	15.6	12.6	(8.0–16.3)	107	20.1	18.5	(15.1–22.1)	.056
Senior high school	260	41.9	37.4	(32.4–43.4)	189	35.5	35.2	(30.9–39.5)	.54
College or above	264	42.5	50.0	(43.0–55.8)	237	44.5	46.4	(41.7–51.0)	.37
Hukou registration									
Shenzhen	80	12.9	13.9	(9.4–17.6)	37	6.9	6.6	(4.6–8.7)	**<.001**
Other cities in Guangdong provinces	112	18.0	22.6	(17.2–28.0)	85	15.9	15.5	(12.6–18.6)	**.010**
Other provinces	429	69.1	63.5	(58.3–69.6)	411	77.1	77.9	(74.5–81.5)	**<.001**
Hometown with high HIV prevalence									.93
No	554	89.2	88.2	(83.8–91.7)	467	87.6	88.4	(85.7–91.1)	
Yes[b]	67	10.8	11.8	(8.3–16.2)	66	12.4	11.6	(8.9–14.3)	
Duration of staying in Shenzhen (years)									
<1	195	31.4	34.5	(28.1–39.8)	150	28.1	29.1	(25.3–33.2)	.13
1–2	79	12.7	10.4	(7.4–14.0)	65	12.2	11.5	(8.7–14.3)	.63
>2	347	55.9	55.1	(49.7–61.3)	318	59.7	59.4	(55.0–63.6)	.24
Monthly income (RMB)									
≤3,000	361	58.1	54.2	(47.8–60.1)	272	51.0	50.1	(45.4–54.8)	.30
3,001–5,000	158	25.4	26.4	(21.0–31.5)	153	28.7	28.9	(25.0–32.9)	.46
>5,000	102	16.4	19.4	(14.9–24.7)	108	20.3	21.0	(17.5–24.6)	.61
Marital status									.075
Unmarried	512	82.4	79.6	(74.2–84.5)	390	73.2	73.4	(69.1–77.2)	
Married	109	17.6	20.4	(15.5–25.8)	143	26.8	26.6	(22.8–30.9)	
Sexual behavior									
Self-identified sexual orientation									
Homosexual/gay	441	71.0	70.8	(65.4–76.3)	307	57.6	57.9	(53.5–62.3)	**<.001**
Bisexual	139	22.4	21.6	(17.1–26.3)	180	33.8	33.7	(29.5–38.1)	**<.001**
Heterosexual or unsure	41	6.6	7.6	(4.8–10.7)	46	8.6	8.4	(5.8–11.0)	.70
Gender of first sex partner									**.014**
Male	429	69.1	68.7	(63.1–74.0)	318	59.7	59.8	(55.4–64.3)	
Female	192	30.9	31.3	(26.0–36.9)	215	40.3	40.2	(35.7–44.6)	
Age of first sex experience									.79
≤20	355	57.2	50.9	(45.2–56.8)	266	49.9	50.4	(46.1–54.9)	
>20	266	42.8	49.1	(43.2–54.8)	267	50.1	49.6	(45.1–53.9)	

Table 1 continued

Characteristic	RDS crude ($N = 621$)		RDS adjusted		TLS crude ($N = 533$)		TLS adjusted		*p* value
	n	*n*/*N* (%)	*n*/*N* (%)	(95 % CI)	*n*	*n*/*N* (%)	*n*/*N* (%)	(95 % CI)	
Type of sex partners in the last 6 months									**.002**
Men only	552	88.9	89.0	(85.3–92.3)	431	80.9	80.8	(77.4–84.0)	
Men and women	69	11.1	11.0	(7.7–14.7)	102	19.1	19.2	(16.0–22.6)	
Number of anal sex partners in the last 6 months									
0	35	5.6	7.6	(4.8–11.6)	44	8.3	8.6	(6.1–11.5)	.66
1	169	27.2	39.5	(33.8–46.0)	114	21.4	21.5	(11.9–25.1)	**<.001**
>1	417	67.1	52.9	(46.1–58.3)	375	70.4	70.0	(65.7–74.2)	**<.001**
Hong Kong male sex partner in the last 6 months									.23
Yes	89	14.3	9.7	(6.8–12.4)	56	10.5	11.7	(8.7–10.1)	
No	532	85.7	90.3	(87.6–93.2)	477	89.5	88.3	(89.9–91.3)	
Anal sex role in the last 6 months[c]									
Insertive	253	43.2	45.0	(38.8–50.7)	214	43.8	43.2	(38.7–47.9)	.63
Both	167	28.5	30.3	(24.9–36.4)	204	41.7	42.3	(37.5–47.2)	**.002**
Receptive	166	28.3	24.7	(19.9–30.4)	71	14.5	14.5	(11.4–18.3)	**<.001**
Unprotected anal intercourse in the last 6 months									.077
Yes	316	50.9	52.1	(46.0–58.1)	247	46.3	45.4	(41.1–49.6)	
No	305	49.1	47.9	(41.9–54.0)	286	53.7	54.6	(50.4–58.9)	
Condom rupture during anal intercourse									
Never	418	67.3	66.3	(61.0–72.4)	378	70.9	71.2	(67.4–75.0)	.16
Yes	76	12.2	10.4	(6.8–14.1)	73	13.7	13.2	(10.3–16.0)	.27
Unsure	103	16.6	16.5	(12.5–20.6)	60	11.3	11.4	(8.9–14.0)	**.032**
NA (no condom use)	24	3.9	6.8	(3.5–10.3)	22	4.1	4.2	(2.5–6.2)	.18
Number of female sex partners in the last 6 months									
0	522	84.1	84.4	(80.6–88.6)	434	81.4	82.0	(78.6–85.2)	.38
1	73	11.8	13.5	(9.3–17.4)	85	15.9	15.5	(12.2–18.9)	.48
>1	26	4.2	2.1	(1.1–3.2)	14	2.6	2.5	(1.3–4.0)	.66
Unprotected sex with females in the last 6 months									.10
Yes	63	10.1	9.8	(6.7–13.2)	75	14.1	13.7	(10.8–16.7)	
No	558	89.9	90.2	(86.8–93.3)	458	85.9	86.3	(83.3–89.2)	
STI history, drug use, HIV knowledge, use of services									
Diagnosed with STIs in the last year									.93
No	533	85.8	89.2	(85.8–92.1)	477	89.5	89.0	(86.1–91.6)	
Yes	88	14.2	10.8	(7.9–14.2)	56	10.5	11.0	(8.4–13.9)	
Used illicit drugs in the last 6 months									.80
No	597	96.1	97.6	(95.7–98.9)	520	97.6	97.3	(95.7–98.7)	
Yes	24	3.9	2.4	(1.1–4.3)	13	2.4	2.6	(1.3–4.3)	
HIV-related knowledge									.71
Low	53	8.5	9.1	(5.7–13.3)	56	10.5	10.0	(7.5–12.6)	
High	568	91.5	90.9	(86.7–94.3)	477	89.5	90.0	(87.4–92.5)	
Condom use knowledge									.16
Low	91	14.7	10.5	(7.8–14.2)	70	13.1	13.7	(10.8–16.8)	
High	530	85.3	89.5	(85.8–92.2)	463	86.9	86.3	(83.2–89.2)	
Self-perceived HIV risk									
Very low	481	77.5	80.8	(75.2–84.2)	441	82.7	82.1	(78.6–85.4)	.64
Moderate	121	19.5	17.1	(13.8–22.4)	78	14.6	15.2	(12.0–18.6)	.48
Very high	19	3.1	2.0	(0.9–3.6)	14	2.6	2.7	(1.3–4.2)	.52

Table 1 continued

Characteristic	RDS crude ($N=621$)		RDS adjusted		TLS crude ($N=533$)		TLS adjusted		p value
	n	n/N (%)	n/N (%)	(95 % CI)	n	n/N (%)	n/N (%)	(95 % CI)	
Access to HIV-related services in the last year									**.001**
No	166	26.7	31.1	(25.3–36.9)	107	20.1	20.0	(16.3–23.6)	
Yes	455	73.3	68.9	(63.1–74.7)	426	79.9	80.0	(76.4–83.7)	
Tested for HIV in the last year									.008
No	359	57.8	61.1	(55.0–66.5)	275	51.6	51.1	(46.6–55.5)	
Yes	262	42.2	38.9	(33.5–45.0)	258	48.4	48.9	(44.5–53.4)	

The bold values indicate statistically significant at $p < .05$

[a] Low-end venues: parks, recreational centers or saunas; high-end venues: bars/massage centers/gyms

[b] Provinces where HIV prevalence is higher than 10 % in mainland China, i.e., Sichuan, Chongqing, Yunnan and Guizhou

[c] 35 MSM by RDS and 44 MSM by TLS had no anal sex in the last 6 months

identified and to engage in risky sexual behaviors. On the other hand, MSM recruited by TLS were more likely to be covered by HIV-related intervention services. Our study, for the first time, shows that TLS is more effective to reach core high-risk MSM than RDS.

During the same survey period, RDS reached a larger number of MSM, and of the 49 participants attending both the RDS and TLS surveys, the majority (82 %, 40/49) attended the RDS survey first. This indicates that RDS is more effective to reach MSM than TLS. However, contrary to the RDS theory and previous evidence that RDS can reach a more marginalized population of MSM than TLS (Kendall et al., 2008; Paz-Bailey et al., 2013; Wei et al., 2012), TLS MSM in our study were less likely to have Shenzhen *hukou* registration, less educated and more likely to be non-gay identified than RDS MSM. We explain these results as follows: first, as homosexuality is not largely accepted by the society, MSM in China usually hide their same sex activities from their peers, friends, and relatives while living in their hometown (Feng et al., 2010). Compared with the MSM who migrated from other places, native Shenzhen MSM residents may feel more reluctant to seek partners at venues. The higher proportion of migrant MSM may have consequently resulted in a higher proportion of less educated subjects in the TLS survey than that in the RDS survey. Compared to native residents, migrants tend to have limited education and relatively low social status (He, 2007), which may be the same for migrant MSM in Shenzhen. Second, there is evidence that MSM who search partners over the internet are younger and more educated than venue-based MSM (Guo et al., 2011; Tsui & Lau, 2010). As TLS can only sample MSM who physically attend venues, it is thus understandable that MSM recruited by TLS were older and less educated than those recruited by RDS. Third, in Shenzhen, public health authorities through the local CDC have collaborated with a NGO for nearly 10 years. With efforts from the local CDC and MSM peers of the NGO, venues including small parks, recreational centers, and saunas that are often invisible were very well mapped. This provides us a good opportunity to tap into the more marginalized MSM by TLS. In our TLS survey, the majority of MSM were recruited from low-end venues (parks, recreational centers or saunas) where quick and unsafe sex often occurs. Previous studies of Chinese MSM have revealed that MSM who attend these low-end venues are often more marginalized, e.g., who tend to be older, less educated and more likely to be married and identify themselves as non-gay (Zhao et al., 2013). Finally, different from TLS, RDS uses social networking in the recruitment process. In societies where stigma is attached to MSM, those MSM who identify themselves as non-gay tend to be less likely to connect with the MSM community than those MSM who identify themselves as gay (Benoit, Pass, Randolph, Murray, & Downing, 2012; Dodge et al., 2012). In our RDS survey, we selected 3 non-gay identified MSM as seeds, although they were able to prolong the recruitment chains, we found that the recruitment was often stopped when a new non-gay identified MSM was enrolled.

Our results have important insights for sampling methodologies in HIV and other sexuality-related research fields. In such research fields, sensitive issues or marginalized populations are often involved, making it difficult to acquire representative data. Our study and previous research revealed that both RDS and TLS can successfully sample marginalized populations such as MSM, female sex workers, drug users and migrants (Ferreira et al., 2008; Johnston, Sabin, Hien, & Huong, 2006; McKnight et al., 2006). We highly recommend researchers to consider these two sampling methodologies to improve representativeness of their data when targeting marginalized populations. If researchers can completely map venues where targeted populations congregate, TLS actually can very well tap into the more marginalized segments and acquire a sample of good representativeness. When the target populations are not very well connected, researchers may

Table 2 Comparison of risk factors of HIV infection between 621 men who have sex with men (MSM) by respondent-driven sampling (RDS) and 533 MSM by time-location sampling (TLS) in Shenzhen, China in 2010, derived from weighted multivariate logistic regressions

Characteristic	RDS ($N=621$)			TLS ($N=533$)		
	AOR	(95% CI)	p	AOR	(95% CI)	p
Demographic						
Hometown with high HIV prevalence						
No	1.00					
Yes[a]	2.44	(1.07–5.55)	**.034**			
Monthly income (RMB)						
≤3,000				1.00		
>3,000				0.46	(0.25–0.84)	**.012**
Sexual behavior						
Type of sex partners in the last 6 months						
Men only				1.00		
Men and women				0.35	(0.13–0.97)	**.043**
Condom rupture during anal intercourse			**.049**			
Never	1.00					
Yes	0.84	(0.30–2.36)	.74			
Unsure	0.20	(0.05–0.77)	.019			
NA (no condom use)	1.97	(0.70–5.55)	.20			
Multiple anal sex partners in the last 6 months						
No	1.00					
Yes	2.21	(1.09–4.48)	**.027**			
STI history, drug use, HIV knowledge, use of services						
Diagnosed with STIs in the last year						
No	1.00					
Yes	3.85	(1.84–8.04)	**<.001**			
Access to HIV-related services in the last year						
Yes	1.00					
No	3.66	(1.93–6.93)	**<.001**			
Self-perceived HIV risk			**.017**			
Very low	1.00					
Moderate	2.41	(1.17–4.96)	.017			
Very high	4.61	(1.03–20.59)	.045			

The bold values indicate statistically significant at $p<.05$

The data and the univariate results are presented in Tables S3 and S4. *AOR* adjusted odds ratio

[a] Provinces where HIV prevalence has exceeded 10 % in mainland China, i.e., Sichuan, Chongqing, Yunnan and Guizhou

consider using TLS instead of RDS as the sampling method. If using RDS, researchers should select "popular seeds" who have personal networks with the more marginalized segments to acquire a sample of good representativeness. Moreover, we compared the RDS crude estimates of frequency data with the TLS adjusted estimates (results not shown) and the p values differed a lot from that shown in Table 1. It highlights the importance of weighting in RDS. We recommend researchers to use weighting information when analyzing RDS data, otherwise results would not be accurate. Furthermore, as our study identifies significant differences between the samples recruited by RDS and TLS, researchers should be consistent in applying sampling methods when evaluating trends over time.

In our study, TLS MSM were more likely to report risky sexual behavior, in terms of having both male and female partners, engaging in both receptive and insertive sex role and having multiple anal sex partners. On the other hand, TLS MSM were also more likely to have used HIV-related intervention services, i.e., condom promotion, peer education, and HIV counseling. Inconsistent with our study, a study in Guatemala found that the utilization of HIV-related services was more common among RDS MSM than that among TLS

MSM, because outreach activities in gay venues were usually not allowed by gatekeepers of gay venues there (Paz-Bailey et al., 2013). While in Shenzhen, MSM peers were trained by the public health authorities and have been delivering HIV-related intervention services to MSM in gay venues in a friendly way for both gatekeepers and MSM (Tan et al., 2013). The common access to HIV-related intervention services among TLS MSM may have decreased their risks of getting HIV or syphilis. Therefore, the HIV infection rate was comparable and the syphilis infection rate was even lower in TLS MSM than that in RDS MSM in our study.

Our study provided evidence regarding the increasingly high prevalence of HIV and syphilis among MSM in Shenzhen. The prevalence of HIV and syphilis in the current TLS survey is higher than in previous TLS surveys in Shenzhen (Zhao et al., 2013). We also found that the prevalence of HIV and syphilis among MSM in Shenzhen was higher than in several other cities in China that had been similarly surveyed (Fan et al., 2012; Huan et al., 2013; Tang et al., 2013). Based on our results, strategies targeting factors associated with HIV are needed to prevent the HIV epidemic from further expanding among MSM in Shenzhen.

Although the RDS and TLS surveys showed comparable HIV prevalence, the risk factors of HIV identified by these two surveys were completely different. Many of the risk factors identified in the RDS survey are also commonly reported worldwide by previous studies (Baral et al., 2009; Berry et al., 2012; Choi, Ayala, Paul, Boylan, & Gregorich, 2013; Zhang et al., 2013). While in the TLS survey, only having a low income and having male sex partners only (vs. having both male and female partners) were associated with HIV infection. In our surveys, sexual behaviors were measured either within a time frame of the last 6 months, whereas HIV-related services utilization was reported within a time frame of the last year. It is thus very likely that a certain proportion of the TLS participants engaging in high-risk behavior, such as having multiple anal sex partners, has received information on reducing HIV risks and subsequently adjusted their risk behaviors. As the majority of the TLS MSM have used HIV-related intervention services in the year prior to the survey, it is possible that this common access to HIV-related services has counteracted the risk of getting HIV infected in the key subgroups engaging in high-risk behaviors. Over the past decade, most of the intervention control efforts in Shenzhen were targeted to MSM attending gay venues, and these efforts turned out to be acceptable and effective (Tan et al., 2013). However, internet-based MSM tend to be neglected by such intervention efforts. As there is evidence that internet is commonly used nowadays by MSM to seek quick sex (Ko et al., 2012; Zhang et al., 2007), we recommend public health authorities to pay more attention to these internet-based MSM. Risk factors identified in the RDS survey may be informative for designing HIV prevention and control programs and internet may be an important channel to disseminate such prevention programs.

There are several limitations to our study. Firstly, both the RDS and the TLS surveys are susceptible to recall bias and social desirability bias, as the majority of variables are self-reported. However, given that questionnaires were the same in the RDS and TLS surveys, we expect that these sources of biases would affect both samples in a similar way. Secondly, all our participants were willing to be tested in the current study. Those who refused to participate in our study may have refused because they just have been tested recently, or because they were afraid of a positive result, or because they did not have any unsafe sexual practices and believed that testing is not needed. These refusals could cause response bias, especially considering that the overall refusal rate was high: 35 % among TLS MSM. The refusal rate among RDS MSM was not retained, but can be reflected by the low coupon return rate (33 %). Furthermore, both the RDS and TLS surveys are cross-sectional, thus casual inferences cannot be made.

In conclusion, the findings of the comparison between RDS and TLS in this study highlight that RDS is not necessarily a more effective method to reach the more marginalized population of MSM. Under certain circumstances, such as in Shenzhen where population movement is common and venues are very well mapped, TLS is more effective to reach the hidden segments of MSM. On the other hand, as TLS can only reach MSM who physically attend venues and HIV-related intervention services are already commonly available at gay venues in Shenzhen, RDS is more informative for allocating prevention efforts than TLS. Researchers and public health authorities should take into account the different sample compositions of RDS and TLS and be consistent in applying sampling methods when evaluating trends over time.

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