Nitrite inhalants use, sexual behaviors and HIV/syphilis infection among men who have sex with men in Chongqing, China

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Abstract

Background: Emerging evidence indicates nitrite inhalants have become increasingly prevalent among men who have sex with men (MSM). The present study aimed to describe the prevalence and correlates of nitrite inhalants use and its association with risky sexual behaviors and human immunodeficiency virus (HIV)/syphilis infection among MSM in Chongqing, a city in China where MSM were burdened with the highest pooled HIV prevalence in the country.

Methods: This cross-sectional study was conducted in Chongqing between March 2019 and February 2020. Information of demographics, drug use, sexual behaviors and HIV testing was collected through an anonymous survey. Blood samples were drawn from each participant for the diagnoses of HIV and syphilis. Logistic regression analysis was performed to evaluate factors correlated with nitrite inhalants use and its relationship with risky sexual behaviors and HIV/syphilis infection.

Results: Of the 1151 eligible participants, 18.9% (218) reported use of at least one type of recreational drugs in the past 6 months, and nitrite inhalants were the most commonly used substance (17.7, 95% confidence interval [CI]: 15.6–20.2%). The proportions of participants reported engaging in group sex and practicing condomless internal ejaculation during anal sex in the past six months were 5.8% (95% CI: 4.4–7.2%) and 41.7% (95% CI: 38.7–44.7%), respectively. The general prevalence of HIV and syphilis infection among the enrolled MSM were 16.8% (95% CI: 14.7–19.0%) and 12.6% (95% CI: 10.7–14.4%), respectively. Factors positively associated with nitrite inhalants use included: age ≤ 25 (adjusted odds ratio [aOR] = 2.08, 95% CI: 1.10–3.94), monthly individual income ≥ CNY 3000 (Chinese Yuan) (aOR = 1.95, 95% CI: 1.18–3.22), preferring receptive anal intercourse (aOR = 2.27, 95% CI: 1.34–3.84) and versatile anal intercourse (aOR = 2.60, 95% CI: 1.64–4.13), age at first anal intercourse < 18 (aOR = 1.79, 95% CI: 1.21–2.67), engaging in group sex in the past six months (aOR = 9.34, 95% CI: 4.95–17.63), having multiple male sex partners in the past 6 months (aOR = 2.32, 95% CI: 1.50–3.58), practicing CIE during anal sex in the past six months (aOR = 1.71, 95% CI: 1.19–2.46), HIV infection (aOR = 1.72, 95% CI: 1.11–2.66) and syphilis infection (aOR = 1.98, 95% CI: 1.23–3.17).

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Background

Despite the achievements obtained in human immuno-deficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) control and prevention in China, national updates on the AIDS/sexually transmitted diseases (STDs) epidemic indicated that men who have sex with men (MSM) were at increasing risk of HIV infection in the past decades. In 2017, 25.5% of the 134,512 newly diagnosed HIV cases were attributed to sex between men [1], while sexual contacts between men only accounted for 12.2% of the 50,000 new infections in 2007 [2]. The rapid spread of the HIV epidemic among MSM has posed great challenges to HIV/AIDS prevention in China.

Recent studies revealed that recreational drugs were increasingly popular among MSM in China [3–5]. Recreational drug use was reported to be associated with risky sexual behaviors, which placed users at elevated risk of HIV and STDs [5–7]. Previous studies reported that methamphetamine or ecstasy was the most prevalent recreational drug among MSM [8–10]. However, recent findings suggested nitrite inhalants (also referred to as rush poppers) had taken the place of methamphetamine or ecstasy and become the most popular recreational substance among MSM in China [11, 12].

Reports from western countries documented that MSM nitrite inhalants users were more likely to engage in risky sexual behaviors and were involved in greater likelihood of HIV acquisition [13, 14]. However, studies assessing the associations between nitrite inhalants use and risky sexual behaviors, HIV infection and STDs are rather limited in China. Only a very small number of studies in north and east coastal metropolises of China (e.g., Beijing, Nanjing and Shenyang) addressed nitrite inhalants use among the subpopulation currently at risk. The prevalence of nitrite inhalants use, especially nitrite inhalants use, among the subgroup currently remained unknown. The present study aimed to describe the prevalence and correlates of nitrite inhalants use, as well as its associations with risky sexual behaviors and HIV/syphilis infection among MSM in this under-researched area, which could confirm and further extend the existing literature. Moreover, clarification of the issues might potentially contribute to the implementation of a more tailored and comprehensive HIV prevention strategy among MSM in China.

Methods

Study design and participants

This cross-sectional study was conducted from March 2019 to February 2020 in Chongqing. To be eligible to participate in the study, MSM had to be male, 18 years or older, have had sexual contact with men in the previous 12 months and were willing to provide written informed consent. The local community-based organization (CBO) covering the largest number of MSM was chosen as the recruitment site and MSM participants were recruited using the convenience sampling method.

Participants who provided written informed consent completed a self-administered anonymous survey in a designated room at the CBO. Each MSM participant was paid CNY 25 (Chinese Yuan) (about USD 4, United States Dollar) as remuneration. The protocol of this study was reviewed and approved by the Ethics Committee of the people’s hospital of Chongqing Tongliang District and the people’s hospital of Chengdu Tianfu New Area.

Data collection

It took participants approximately 15 min to complete the paper-and-pencil questionnaire. The following information was collected: socio-demographic characteristics (including age, official residence location, education level, occupation, marital status and monthly individual income), types of drug used (including nitrite inhalants, capsule zero [5-MEO-DIPT, foxy], methamphetamine, ecstasy, magu [a kind of tablets which consist of methamphetamine and caffeine], ketamine, happy water [a mixture of crystal methamphetamine, ecstasy and ketamine], GHB [gamma-hydroxybutyrate], cannabis, bath salt [or cathinone], red crystal meth [extracts from methamphetamine] and heroin), sexual behaviors...
(including sexual orientation, preferred sexual role with males, age at first anal intercourse, route to seek male sex partners, unprotected anal intercourse [UAI] with regular partners and casual partners, number of male sex partners, group sex and condomless internal ejaculation [CIE] during anal sex in the past six months) and experience of HIV testing in the past six months.

Laboratory testing
A 5-ml blood specimen was drawn from each participant to test their syphilis and HIV antibodies. For syphilis identification, the Treponema pallidum particle assay (TPPA) (Alere Medical Co., Ltd., Chiba Prefecture, Japan) was conducted, and cases with positive results were confirmed by the Toluidine red unheated serum test (TRUST) (Rongsheng Biotec, Shanghai, China). Participants who were tested positive in both TPPA and TRUST tests were considered as syphilis infection. For HIV evaluation, a rapid test (Determine HIV-1/2, Alere Medical Co., Ltd., Chiba Prefecture, Japan) and enzyme-linked immunosorbent assay (ELISA) (HIV Combo, Alere Medical Co., Ltd., Chiba Prefecture, Japan) were used to screen HIV antibodies, and positive cases were further confirmed by the western blot assay (HIV Blot 2.2 WB, MP Biomedicals Co., Ltd., Singapore) in the central lab of Chongqing Center for Disease Control and Prevention.

Data analysis
Data were double entered using Epi Data software 3.1 (The Epi Data Association, Odense, Denmark) and analyzed using SPSS 16.0 (SPSS, Inc., Chicago, IL, USA) and SAS software 9.4 (SAS, Inc., Cary, NC, USA). Chi-square tests were used to compare the differences in socio-demographics, sexual behaviors, experience of HIV testing and HIV/syphilis infection between nitrite inhalants users and nonusers. Logistic regression analysis was employed to determine factors correlated with nitrite inhalants use. Variables with \( P < 0.05 \) in the univariate analysis were further entered into a multivariate stepwise logistic regression model and variables significant at \( P < 0.05 \) were retained in the final model. To examine the robustness of our results, Poisson regression model with robust standard error estimation was used to conduct sensitivity analysis, and prevalence ratios (PR) and 95% CI were obtained.

Power analysis
The present analysis was part of a larger study which was designed to explore the prevalence of recreational drug use and its association with HIV/STDS among MSM in Chongqing. As no data on the prevalence of recreational drug use among MSM were reported before in this area, we referred to a recent survey from the neighboring Sichuan province reporting 27.7% of the MSM participants had ever used recreational drugs [5]. A sample size of 1044 was estimated based on an ability to detect changes in proportion of 10% from the estimated prevalence, with a power of 90% and a significance level of 5%. To obtain the estimated sample size, staff from the CBO introduced the study to the potential participants when they reached out in community to carry out health education activities and provided voluntary counseling and testing at the CBO. Enrolled participants were also encouraged to recommend their MSM peers.

Results

Characteristics of participants
In total, the CBO staff members managed to recruit 1162 potential participants and 11 (0.9%) MSM were excluded for declining to provide written informed consent. Thus, 1151 MSM were enrolled in the study. Of all the participants included, the average age was 30.44 years (standard deviation \[ SD \] = 9.35), and about three-fourths (74.4%) of them officially resided in Chongqing city. Over two-thirds (68.9%) had obtained at least a college education degree, and most (79.5%) of the MSM participants were single. More than two-thirds (66.9%) reported to be service providers or solo business owners, and the majority (81.1%) reported a monthly individual income of CNY 3000 or more (Table 1).

Overall, most (66.7%) of the eligible participants claimed to be homosexual, and one-fifths (20.9%) of the participants reported their age at first anal intercourse was under 18 years old. The majority (67.2%) of them used gay applications to seek male sex partners, and over half (59.9%) reported having multiple sex partners in the previous six months. The proportion of MSM reporting UAI in the past six months with “regular sex partners” and with “casual sex partners” was 41.5 and 33.0%, respectively. 5.8% of the participants reported engaging in group sex, and over two-fifths (41.7%) practiced CIE during anal sex in the past six months. In this study, more than one-third (37.2%) of MSM had HIV testing experience in the past six months, and the laboratory test results showed that the general prevalence of HIV and syphilis infection among the enrolled MSM were 16.8% (95% CI: 14.7–19.0) and 12.6% (95% CI: 10.7–14.4), respectively (Table 2).

Among the 1151 participants in survey, 18.9% (218) reported having used at least one type of recreational drug in the past 6 months, of whom 20.6% (45) were polydrug users. Of all participants, 17.7% (204) reported use of nitrite inhalants in the past six months, followed by 4.5% (52) use of methamphetamine, 1.0% (12) use of magu, 0.3% (3) use of zero capsule, 0.3% (3) use of ketamine and 0.1% (1) use of cannabis, ecstasy, bath salt, red crystal meth and heroine, respectively. Compared with
non-users, nitrite inhalants users were more likely to initiate anal intercourse at an earlier stage, seek sexual partners through gay applications, prefer receptive or versatile anal intercourse, practice sexual behaviors (including UAI with regular and casual sexual partners, multiple sex partners, group sex and CIE during anal sex), have experience of HIV testing and be HIV/syphilis positive (Table 2).

Factors associated with nitrite inhalants use
Univariate analysis showed the following variables were positively associated with nitrite inhalants use ($P < 0.05$): age ≤ 25 years old, working in service industry, being solo business owners or others, being single, monthly individual income ≥ CNY 3000, preferring receptive or versatile anal intercourse, age at first anal intercourse < 18 years, seeking sex partners through gay applications, having multiple sex partners, engaging in group sex, practicing CIE during anal sex, having HIV testing experience in the past six months and HIV/syphilis infection (Table 3).

In the final multivariate logistic regression model, nitrite inhalants use was significantly correlated with age ≤ 25 years old (odds ratio $[OR] = 2.08$, 95% CI: 1.10–3.94), monthly individual income ≥3000 CNY ($OR = 1.95$, 95% CI: 1.18–3.22), preferring receptive ($OR = 2.27$, 95% CI: 1.34–3.84) or versatile anal intercourse ($OR = 2.60$, 95% CI: 1.64–4.13), age at first anal intercourse < 18 years ($OR = 1.79$, 95% CI: 1.21–2.67), engaging in group sex in the past 6 months ($OR = 9.34$, 95% CI: 4.95–17.63), having multiple sex partners in the past six months ($OR = 2.32$, 95% CI: 1.50–3.58), practicing CIE during anal sex in the past six months ($OR = 1.71$, 95% CI: 1.19–2.46), HIV infection ($OR = 1.72$, 95% CI: 1.11–2.66) and syphilis infection ($OR = 1.98$, 95% CI: 1.23–3.17), ($P < 0.05$).

In the multivariate Poisson regression analysis, factors significantly associated with nitrite inhalants use were consistent with those in the multivariate logistic regression analysis (Table 4), namely: age ≤ 25 years old ($PR = 1.04$, 95% CI: 1.01–1.07), monthly individual income ≥ 3000 CNY ($PR = 1.04$, 95% CI: 1.01–1.09), preferring receptive ($PR = 1.04$, 95% CI: 1.01–1.07) or versatile anal intercourse ($PR = 1.05$, 95% CI: 1.03–1.09), engaging in group sex in the past 6 months ($PR = 1.05$, 95% CI: 1.03–1.08), age at first anal intercourse < 18 years ($PR = 1.05$, 95% CI: 1.02–1.09), engaging in group sex in the past six months ($PR = 1.05$, 95% CI: 1.03–1.07), practicing CIE during anal sex in the past six months ($PR = 1.03$, 95% CI: 1.01–1.06), HIV infection ($PR = 1.05$, 95% CI: 1.01–1.09) and syphilis infection ($PR = 1.06$, 95% CI: 1.02–1.10), ($P < 0.05$).

### Table 1  Socio-demographic characteristics among MSM by nitrite inhalants use status (N = 1151)

| Characteristics | n     | Percentage, 95% CI | Nitrite inhalants users (n, %) | Non-users (n, %) | P value |
|-----------------|-------|-------------------|-------------------------------|-----------------|---------|
| **Age (years), mean ± SD** |       |                   |                               |                 |         |
| ≤ 25            | 410   | 35.6 (32.9–38.5)   | 82 (40.2)                     | 328 (34.6)      | 0.001   |
| 26–35           | 491   | 42.7 (39.7–45.4)   | 98 (48.0)                     | 393 (41.5)      |         |
| > 35            | 250   | 21.7 (19.5–24.2)   | 24 (11.8)                     | 226 (23.9)      |         |
| **Residence in Chongqing** |       |                   |                               |                 |         |
| Yes             | 856   | 74.4 (71.9–76.8)   | 148 (72.5)                    | 708 (74.8)      | 0.511   |
| No              | 295   | 25.6 (23.2–28.1)   | 56 (27.5)                     | 239 (25.2)      |         |
| **Education**   |       |                   |                               |                 |         |
| Senior high school and below | 358   | 31.1 (28.4–33.7)   | 64 (31.4)                     | 294 (31.0)      | 0.927   |
| College and above | 793   | 68.9 (66.3–71.6)   | 140 (68.6)                    | 653 (69.0)      |         |
| **Occupation**  |       |                   |                               |                 |         |
| Enterprise, public institution or government | 186   | 16.2 (14.1–18.2)   | 23 (11.3)                     | 163 (17.2)      | 0.002   |
| Service industry, solo business owner | 770   | 66.9 (64.0–69.5)   | 158 (77.4)                    | 612 (64.6)      |         |
| Retired, unemployed or student | 195   | 16.9 (14.9–19.1)   | 23 (11.3)                     | 172 (18.2)      |         |
| **Marital status** |       |                   |                               |                 |         |
| Never married   | 915   | 79.5 (77.0–81.8)   | 180 (88.2)                    | 735 (77.6)      | < 0.001 |
| Married         | 162   | 14.1 (12.1–16.2)   | 11 (5.4)                      | 151 (16.0)      |         |
| Divorced or widowed | 74    | 6.4 (5.0–7.8)      | 13 (6.4)                      | 61 (6.4)        |         |
| **Individual monthly income (CNY)** |       |                   |                               |                 |         |
| < 3000          | 217   | 18.9 (16.6–21.1)   | 25 (12.3)                     | 192 (20.3)      | 0.008   |
| ≥ 3000          | 934   | 81.1 (78.9–83.4)   | 179 (87.7)                    | 755 (79.7)      |         |

MSM: Men who have sex with men, CI: Confidence interval, SD: Standard deviation, CNY: Chinese Yuan.
**Table 2** Sexual behaviors and health outcomes among MSM by nitrite inhalants use status (N = 1151)

| Characteristics                                      | n   | Percentage, 95% CI       | Nitrite inhalants users (n, %) | Non-users (n, %) | P value |
|-------------------------------------------------------|-----|--------------------------|--------------------------------|------------------|---------|
| **Sexual orientation**                                |     |                          |                                |                  |         |
| Homosexual                                            | 768 | 66.7 (64.0–69.2)         | 167 (81.9)                     | 601 (63.5)       | < 0.001 |
| Bisexual                                              | 320 | 27.8 (25.5–30.2)         | 35 (17.1)                      | 285 (30.1)       |         |
| Uncertain                                             | 63  | 5.5 (4.3–6.9)            | 2 (1.0)                        | 61 (6.4)         |         |
| **Age at first anal intercourse (years)**              |     |                          |                                |                  |         |
| < 18                                                  | 241 | 20.9 (18.5–23.3)         | 73 (35.8)                      | 168 (17.7)       | < 0.001 |
| ≥ 18                                                  | 910 | 79.1 (76.7–81.5)         | 131 (64.2)                     | 779 (82.3)       |         |
| **Seeking sex partners through gay applications in the past 6 months** |     |                          |                                |                  |         |
| Yes                                                   | 774 | 67.2 (64.5–69.9)         | 166 (81.4)                     | 608 (64.2)       | < 0.001 |
| No                                                    | 377 | 32.8 (30.1–35.5)         | 38 (18.6)                      | 339 (35.8)       |         |
| **Preferring sexual role with males**                 |     |                          |                                |                  |         |
| Insertive anal intercourse                             | 383 | 33.3 (30.7–36.1)         | 33 (16.2)                      | 350 (36.9)       | < 0.001 |
| Receptive anal intercourse                             | 265 | 23.0 (20.7–25.4)         | 56 (27.4)                      | 209 (22.1)       |         |
| Versatile anal intercourse                             | 503 | 43.7 (41.0–46.6)         | 115 (56.4)                     | 388 (41.0)       |         |
| **UAI with regular partners in the past 6 months**    |     |                          |                                |                  |         |
| Yes                                                   | 301 | 41.5 (37.7–44.9)         | 84 (55.6)                      | 217 (37.7)       | < 0.001 |
| No                                                    | 425 | 58.5 (55.1–62.3)         | 67 (44.4)                      | 358 (62.3)       |         |
| **UAI with casual partners in the past 6 months**     |     |                          |                                |                  |         |
| Yes                                                   | 248 | 33.0 (29.7–36.3)         | 70 (44.0)                      | 178 (30.0)       | 0.001   |
| No                                                    | 504 | 67.0 (63.7–70.3)         | 89 (56.0)                      | 415 (70.0)       |         |
| **Number of male sex partners in the past 6 months**  |     |                          |                                |                  |         |
| < 2                                                   | 462 | 40.1 (37.4–42.9)         | 39 (19.1)                      | 423 (44.7)       | < 0.001 |
| ≥ 2                                                   | 503 | 43.7 (40.9–46.6)         | 75 (36.8)                      | 428 (45.2)       |         |
| ≥ 5                                                   | 186 | 16.2 (14.0–18.1)         | 90 (44.1)                      | 96 (10.1)        |         |
| **Group sex in the past 6 months**                    |     |                          |                                |                  |         |
| Yes                                                   | 67  | 5.8 (4.4–7.2)            | 49 (24.0)                      | 18 (1.9)         | < 0.001 |
| No                                                    | 1084| 94.2 (92.8–95.6)         | 95 (76.0)                      | 929 (98.1)       |         |
| **Condomless internal ejaculation during anal sex in the past 6 months** |     |                          |                                |                  |         |
| Yes                                                   | 480 | 41.7 (38.7–44.7)         | 116 (56.9)                     | 364 (38.4)       | < 0.001 |
| No                                                    | 671 | 58.3 (55.3–61.3)         | 88 (43.1)                      | 583 (61.6)       |         |
| **HIV testing in the past 6 months**                  |     |                          |                                |                  |         |
| Yes                                                   | 428 | 37.2 (34.6–39.8)         | 91 (44.6)                      | 337 (35.6)       | 0.016   |
| No                                                    | 723 | 62.8 (60.2–65.4)         | 113 (55.4)                     | 610 (64.4)       |         |
| **HIV infection**                                     |     |                          |                                |                  |         |
| Yes                                                   | 193 | 16.8 (14.7–18.9)         | 55 (27.0)                      | 138 (14.6)       | < 0.001 |
| No                                                    | 958 | 83.2 (81.1–85.3)         | 149 (73.0)                     | 809 (85.4)       |         |
| **Syphilis infection**                                |     |                          |                                |                  |         |
| Yes                                                   | 145 | 12.6 (10.7–14.5)         | 44 (21.6)                      | 101 (10.7)       | < 0.001 |
| No                                                    | 1006| 87.4 (85.5–89.3)         | 160 (78.4)                     | 846 (89.3)       |         |

MSM: Men who have sex with men, CI: Confidence interval, UAI: Unprotected anal intercourse, HIV: Human immunodeficiency virus

**Discussion**

The present study explored the prevalence and correlates of nitrite inhalants use and its association with risky sexual behaviors and HIV/syphilis infection among a sample of community-based MSM. Corroborating previous findings [5, 6, 17], nitrite inhalants were found to be the most commonly used recreational substance among MSM in Chongqing. Of the 1151 participants included,
### Table 3  Factors correlated with nitrite inhalants use in the past 6 months (N = 1151)

| Factors                             | Univariate analysis | Multivariate analysis |
|-------------------------------------|---------------------|-----------------------|
|                                     | OR (95% CI)         | P value               | aOR (95% CI)          | P value               |
| **Age (years)**                     |                     |                       |                       |                       |
| > 25                                | 1                   |                       | 1                     |                       |
| ≤ 25                                | 2.35 (1.50–3.69)    | < 0.001               | 2.08 (1.10–3.94)      | 0.024                 |
| **Education**                       |                     |                       |                       |                       |
| College and above                   | 1                   |                       | 1                     |                       |
| Senior high school and below        | 1.02 (0.73–1.41)    | 0.927                 |                       |                       |
| **Residence in Chongqing**          |                     |                       |                       |                       |
| Yes                                 | 1                   |                       | 1                     |                       |
| No                                  | 1.12 (0.80–1.58)    | 0.511                 |                       |                       |
| **Occupation**                      |                     |                       |                       |                       |
| Enterprise, public institution or government | 1 | 1 | 1 |                       |
| Service industry, solo business owners and others | 1.64 (1.03–2.61) | 0.038 | 1.32 (0.78–2.25) | 0.305 |
| **Marital status**                  |                     |                       |                       |                       |
| Married, divorced or widowed        | 1                   |                       | 1                     |                       |
| Single                              | 2.16 (1.38–3.40)    | 0.001                 | 1.17 (0.61–2.22)      | 0.639                 |
| **Monthly individual income (CNY)**|                     |                       |                       |                       |
| < 3000                              | 1                   |                       | 1                     |                       |
| ≥ 3000                              | 1.82 (1.16–2.85)    | 0.009                 | 1.95 (1.18–3.22)      | 0.009                 |
| **Preferring sexual role with males**|                   |                       |                       |                       |
| Insertive anal intercourse           | 1                   |                       | 1                     |                       |
| Receptive anal intercourse           | 2.84 (1.79–4.52)    | < 0.001               | 2.27 (1.34–3.84)      | 0.002                 |
| Versatile anal intercourse           | 3.14 (2.08–4.75)    | < 0.001               | 2.60 (1.64–4.13)      | < 0.001               |
| **Age at first anal intercourse (years)** |                     |                       |                       |                       |
| ≥ 18                                | 1                   |                       | 1                     |                       |
| < 18                                | 2.58 (1.86–3.60)    | < 0.001               | 1.79 (1.21–2.67)      | 0.004                 |
| **Seeking sex partners through gay applications in the past 6 months** | | | |                       |
| No                                  | 1                   |                       | 1                     |                       |
| Yes                                 | 2.44 (1.67–3.55)    | < 0.001               | 1.16 (0.74–1.82)      | 0.522                 |
| **Number of sex partners in the past 6 months** | | | |                       |
| < 2                                 | 1                   |                       | 1                     |                       |
| ≥ 2                                 | 3.42 (2.36–4.95)    | < 0.001               | 2.32 (1.50–3.58)      | < 0.001               |
| **Group sex in the past 6 months**  |                     |                       |                       |                       |
| No                                  | 1                   |                       | 1                     |                       |
| Yes                                 | 16.32 (9.26–28.75)  | < 0.001               | 9.34 (4.95–17.63)     | < 0.001               |
| **Condomless internal ejaculation during anal sex in the past 6 months** | | | |                       |
| No                                  | 1                   |                       | 1                     |                       |
| Yes                                 | 2.11 (1.55–2.87)    | < 0.001               | 1.71 (1.19–2.46)      | 0.004                 |
| **HIV testing in the past 6 months**|                     |                       |                       |                       |
| No                                  | 1                   |                       | 1                     |                       |
| Yes                                 | 1.46 (1.07–1.98)    | 0.016                 | 1.32 (0.93–1.89)      | 0.119                 |
| **HIV infection**                   |                     |                       |                       |                       |
| No                                  | 1                   |                       | 1                     |                       |
| Yes                                 | 2.16 (1.51–3.10)    | < 0.001               | 1.72 (1.11–2.66)      | 0.015                 |
204 (17.7%) reported nitrite inhalants use in the past 6 months, which was higher than 3-month use rate (10.6%) in Shenzhen [12], but lower than reports from metropolises elsewhere in China, such as Shenyang (18.9%) [15], Beijing and Nanjing (29.8%) [17] and lifetime use rate (24.1%) in three cities of Sichuan Province [19]. The reason why nitrite inhalants have outnumbered other illicit drugs and risen in popularity might be attributed to its function on sexual pleasure enhancement, easy accessibility via the internet and not being included in the list of illegal drugs.

Our study found that MSM with younger age and higher monthly individual income were more likely to be nitrite inhalants users, which was consistent with results in previous studies [15, 16]. Younger MSM may be more familiar with the internet and have better access to nitrite inhalants. Meanwhile, nitrite inhalants use might be quite an expenditure to lower-income MSM. Therefore, MSM with such demographic characteristics as younger age and higher income were more likely to use nitrite inhalants than their counterparts. Additionally, several studies have demonstrated that MSM preferring receptive anal intercourse or versatile anal intercourse were more likely to be nitrite inhalants users [12, 16], and a similar result was found in this study. One possible explanation could be that nitrite inhalants have the effect of relaxing the anal sphincter, which could prevent injury and facilitate sex by not causing pain during anal penetration [20, 21]. Furthermore, we found that earlier anal sex experience was correlated with nitrite inhalants use. Similar to findings in this study, prior studies indicated that MSM with earlier anal sex initiation were more likely to engage in risky behaviors, such as substance use, in their later life [22, 23]. Thus, close attention should be given to MSM with characteristics mentioned above, and these subgroups should be a priority for further interventions towards drug use.

Evidence from specific countries revealed nitrite inhalants use was significantly associated with risky sexual behaviors [13, 24, 25]. However, only a small number of studies in China reported the association between nitrite inhalants use and sexual behaviors, like seeking male sexual partners via the internet, having multiple sex partners and practicing UAI [16, 17, 26]. In the present study, we confirmed the association between nitrite inhalants use and multiple sex partnerships. Additionally, we found nitrite inhalants users were more likely to engage in group sex and practice CIE during anal sex in the past 6 months. It was previously reported that MSM commonly use nitrite inhalants or erectile dysfunction medications before or during group sex [25, 27–29]. Nitrite inhalants were known to increase sexual desire, maintain erection and enhance sexual pleasure [16, 21], which might partly explain why MSM were more likely to use nitrite inhalants in the context of group sex. Moreover, similar to other recreational drugs, nitrite inhalants may also affect central nervous system function and influence decision-making [30, 31]. Thus, it is unsurprising that MSM who use nitrite inhalants practice higher levels of CIE during anal sex.

In accordance with prior reports [12, 17], our data indicated that MSM who used nitrite inhalants in the past 6 months were, respectively 1.72 times and 1.98 times, as likely to acquire HIV and syphilis as nonusers. The existing literature [12, 16, 19], as well as findings in this study, demonstrated that nitrite inhalants use was significantly associated with sexual behaviors, such as having multiple sex partners, engaging in group sex, and practicing UAI and CIE, which may contribute to increased odds of HIV and syphilis infection. In addition, we found high prevalence of risky sexual behaviors, HIV and syphilis among both nitrite inhalants-using MSM (27.0% for HIV and 21.6% for syphilis) and nonusers (14.6% for HIV and 10.7% for syphilis), which suggested comprehensive measures were needed to prevent transmission of HIV/STDs among MSM in China.

Several potential limitations should be addressed in this study. Firstly, the evidence for causal relationships between nitrite inhalants use and risky sexual behaviors and HIV/syphilis infection is weak due to the cross-sectional design of the study. Secondly, participants in this study consisted of MSM who volunteered to attend a CBO. Given the fact that not all MSM would be willing to go to a CBO, and that the CBO attendees might be different from those who were not willing to attend a CBO, our study may be subjected to selection bias. Furthermore, the study collected sensitive information on monthly income, drug use and sexual behaviors, and social desirability bias might exist. In order to reduce the respondents’ anxiety and reluctance, the purpose of the

### Table 3
Factors correlated with nitrite inhalants use in the past 6 months (N = 1151) (Continued)

| Factors                      | Univariate analysis | Multivariate analysis |
|------------------------------|---------------------|-----------------------|
|                              | OR (95% CI)         | P value               | aOR (95% CI)         | P value               |
| Syphilis infection           |                     |                       |                       |                       |
| No                           | 1                   |                       | 1                     |                       |
| Yes                          | 2.30 (1.56–3.41)    | < 0.001               | 1.98 (1.23–3.17)      | 0.005                 |

OR Odds ratio, CI Confidence interval, aOR Adjusted odds ratio, HIV Human immunodeficiency virus
Table 4  Poisson regression analysis of factors correlated with nitrite inhalants use in the past 6 months ($N$ = 1151)

| Factors                                      | Multivariate analysis | Prevalence ratio (95% CI) | $P$ value |
|----------------------------------------------|-----------------------|---------------------------|-----------|
| **Age (years)**                              |                       |                           |           |
| $> 25$                                       |                       | 1                         |           |
| $\leq 25$                                    |                       | 1.04 (1.01–1.07)          | 0.025     |
| **Occupation**                               |                       |                           |           |
| Enterprise, public institution or government |                       | 1                         |           |
| Service industry, solo business owners and others |                   | 1.01 (0.99–1.04)          | 0.367     |
| **Marital status**                           |                       |                           |           |
| Married, divorced or widowed                 |                       | 1                         |           |
| Single                                       |                       | 1.01 (0.98–1.04)          | 0.602     |
| **Monthly individual income (CNY)**          |                       |                           |           |
| $< 3000$                                     |                       | 1                         |           |
| $\geq 3000$                                  |                       | 1.04 (1.01–1.09)          | 0.003     |
| **Preferring sexual role with males**        |                       |                           |           |
| Insertive anal intercourse                   |                       | 1                         |           |
| Receptive anal intercourse                   |                       | 1.04 (1.01–1.07)          | 0.004     |
| Versatile anal intercourse                   |                       | 1.05 (1.03–1.08)          | $< 0.001$ |
| **Age at first anal intercourse (years)**    |                       |                           |           |
| $\geq 18$                                    |                       | 1                         |           |
| $< 18$                                       |                       | 1.05 (1.02–1.09)          | 0.003     |
| **Seeking sex partners through gay applications in the past 6 months** | | | |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.01 (0.99–1.03)          | 0.46      |
| **Number of sex partners in the past 6 months** |                   |                           |           |
| $< 2$                                        |                       | 1                         |           |
| $\geq 2$                                     |                       | 1.05 (1.03–1.07)          | $< 0.001$ |
| **Group sex in the past 6 months**           |                       |                           |           |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.37 (1.26–1.49)          | $< 0.001$ |
| **Condomless internal ejaculation during anal sex in the past 6 months** | | | |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.03 (1.01–1.06)          | 0.008     |
| **HIV testing in the past 6 months**         |                       |                           |           |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.02 (1.00–1.05)          | 0.065     |
| **HIV infection**                            |                       |                           |           |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.05 (1.01–1.09)          | 0.018     |
| **Syphilis infection**                       |                       |                           |           |
| No                                           |                       | 1                         |           |
| Yes                                          |                       | 1.06 (1.02–1.10)          | 0.007     |

CI: Confidence interval, HIV: Human immunodeficiency virus
study was fully explained before the survey started and anonymous questionnaire was administered in private rooms. Lastly, the results were based on a self-administered questionnaire survey and might be influenced by recall bias.

Conclusions
This study found nitrite inhalants were commonly used among MSM in Chongqing and MSM who reported nitrite inhalants use were more likely to practice risky sexual behaviors and were at higher probability of HIV and syphilis infection than their counterparts. The findings suggested particular attention and counselling should be given to nitrite inhalants-using MSM and integrate strategies should be tailored to mitigate nitrite inhalants use and its potential risks.

Abbreviations
MSM: Men who have sex with men; HIV: Human immuno deficiency virus; STDs: Sexually transmitted diseases; AIDS: Acquired immune deficiency syndrome; CIE: Condomless internal ejaculation; UAI: Unprotected anal intercourse; TPPA: Treponema pallidum particle assay; TRUST: Toluadine red unheated serum test; ELISA: Enzyme-linked immunosorbent assay; OR: Odds ratio; CI: Confidence interval; aOR: Adjusted odds ratio; SD: Standard deviation; PR: Prevalence ratios; CBO: Community-based organization; CDC: Center for Disease Control and Prevention

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Authors’ contributions
CHL and CJ conceived and designed the study, CHL and CJ performed the data analyses, CJ, HYL and CHL drafted the manuscript and XJ helped to critically review the manuscript. All authors reviewed and approved the final manuscript.

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Availability of data and materials
The datasets used during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
The protocol of this study was reviewed and approved by the Ethics Committee of the people’s hospital of Tongliang District, Chongqing and the people’s hospital of Chongdu Tianfu New Area. Written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
All authors declare that they have no competing interests.

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References
1. National Center for AIDS/STD Control and Prevention, China CDC. Update on the AIDS/STD epidemic in China in December 2017. Chin J AIDS STD. 2018;24(2):111.
2. China State Council AIDS Working Committee Office, UN theme Group on HIV/AIDS in China. Joint Assessment of HIV/AIDS Prevention and Treatment in China (2007). Beijing: China State Council AIDS Working Committee Office; 2007. Available online at: http://www.chinaaids.cn/ddgg/hpgbgq/ zggazbyg/201312/W0201312201518731.255.01.pdf.
3. Luo W, Hong H, Wang XF, McGoogan JM, Rou KM, Wu ZY. Synthetic drug use and HIV infection among men who have sex with men in China: a sixteen-city, cross-sectional survey. PLoS One. 2018;13(7):e020816.
4. He L, Pan XH, Wang N, Yang XJ, Jiang J, Luo Y, et al. New types of drug use and risks of drug use among men who have sex with men: a cross-sectional study in Hangzhou, China. BMC Infect Dis. 2018;18:182.
5. Dai YX, Musumari PM, Chen HL, Huang YL, Techasrivichien T, Sugimomo SP, et al. Recreational drug use, polydrug use and sexual behaviors among men who have sex with men in southwestern China: a cross-sectional study. Behav Med. 2019;45(4):314–22.
6. Zhao PZ, Tang SY, Wang C, Zhang Y, Best J, Tangthanasup TM, et al. Recreational drug use among Chinese MSM and transgender individuals: results from a national online cross-sectional study. PLoS One. 2017;12(1):e0170024.
7. Xu JJ, Qian HZ, Chu ZX, Zhang J, Hu QH, Jiang YJ, et al. Recreational drug use among Chinese men who have sex with men: a risky combination with unprotected sex for acquiring HIV infection. Biomed Res Int. 2014; https://doi.org/10.1155/2014/725361.
8. Liu G, Cai WO, Chen L, Zhao J, Yang ZR, Tan JG, et al. Study on influential factors and epidemiological characteristics of drug abuse among men who have sex with men in Shenzhen. Chin J Dis Control Prev. 2010;14:1063–5.
9. Nehl EJ, Nakayama KK, He N, Huang J, Zheng T, Wong FY, et al. Substance use and sexual risks among general MSM and money boys in Shanghai, China. J Drug Issues. 2012;42(3):263–78.
10. Ramchand R, Fisher MP, Griffin BA, Becker K, Iguchi MY. Drug use among gay and bisexual men at weekend dance parties: the role of intentions and perceptions of peers’ behaviors. AIDS Behav. 2013;17:1540–9.
11. Chen X, Li XL, Zheng J, Zhao JS, He JM, Zhang QG, et al. Club drugs and HIV/STD infection: an exploratory analysis among men who have sex with men in Changsha, China. PLoS One. 2015;10(5):e0126320.
12. Duan CL, Wei L, Cai YT, Chen L, Yang ZR, Tan W, et al. Recreational drug use and risk of HIV infection among men who have sex with men: a cross-sectional study in Shenzhen, China. Drug Alcohol Depend. 2017;181:30–6.
13. Plankey MW, Ostrow DG, Stall R, Cox C, Li XH, Peck J, et al. The relationship between methamphetamine and popper use and risk of HIV seroconversion in the multicenter AIDS cohort study. J Acquir Immune Defic Syndr. 2007;45(1):85–92.
14. Lampinen TM, Matteis K, Chan K, Hogg RS. Nitrite inhalant use among young gay and bisexual men in Vancouver during a period of increasing HIV incidence. BMC Public Health. 2007;7:35.
15. Chu ZX, Xu JJ, Zhang YH, Zhang J, Hu QH, Yun K, et al. Poppers use and sexual partner concurrency increase the HIV incidence of MSM: a 24-month prospective cohort study in Shenyang, China. Sci Rep. 2016;8:24.
16. Zhang H, Teng T, Lu HY, Zhao YL, Liu HJ, Yin L, et al. Poppers use and risky sexual behaviors among men who have sex with men in Beijing, China. Drug Alcohol Depend. 2016;164:62–8.
17. Wang XF, Li YQ, Wu ZY, Tang ZZ, Reilly KH, Nong QX. Nitrite inhalant use and HIV infection among Chinese men who have sex with men in 2 large cities in China. J Addict Med. 2017;11(6):468–74.
18. Dong MI, Peng B, Liu ZF, Ye QN, Liu H, Lu XL, et al. The prevalence of drug use among MSM in China: a large-scale systematic analysis. BMC Infect Dis. 2019;19:1000.
19. Chen HL, Yang Y, Huang YL, Dai YX, Zhang JX. Prevalence of poppers use and its sexual risks among men who have sex with men in southwestern China: a cross-sectional study. BMC Public Health. 2018;18:1103.
20. Rich AJ, Lachowsky NJ, Cui ZS, Sereda P, Lal A, Moore DM, et al. Event-level analysis of anal sex roles and sex drug use among gay and bisexual men in Vancouver, British Columbia, Canada. Arch Sex Behav. 2016;45(6):1443–51.

21. Schwartz C, Fast D, Knight R. Poppers, queer sex and a Canadian crackdown: examining the experiences of alkyl nitrite use among young sexual minority men. Int J Drug Policy. 2020;77:102670.

22. Xu WJ, Zheng LJ, Song JJ, Zhang X, Zhang XM, Zheng Y. Relationship between childhood sexual abuse and HIV-related risks among men who have sex with men: findings from mainland China. Arch Sex Behav. 2018;47(7):1949–57.

23. Mmbaga EJ, Leyna GH, Leshabari MT, Moen K. Early anal sex experience among men who have sex with men in Dar Es Salaam Tanzania: implications for HIV prevention and care. Arch Sex Behav. 2019;49:2045–55.

24. Hambrick HR, Park SH, Palamar JJ, Estreet A, Schneider JA, Duncan DT. Use of poppers and HIV risk behaviours among men who have sex with men in Paris, France: an observational study. Sex Health. 2018;15(4):370–3.

25. Vaccher SJ, Hammoud MA, Boume A, Lea T, Haire BG, Holt M, et al. Prevalence, frequency, and motivations for alkyl nitrite use among gay, bisexual and other men who have sex with men in Australia. Int J Drug Policy. 2020;76:102659.

26. Li DL, Yang XY, Zhang Z, Qi X, Ruan YH, Jia YJ, et al. Nitrite inhalant use and HIV infection among men who have sex with men in China. BioMed Res Int. 2014; http://doi.org/10.1155/2014/365261.

27. Prestage G, Jin FY, Kippax S, Zablotska I, Imrie J, Grulich A. Use of illicit drugs and erectile dysfunction medications and subsequent HIV infection among gay men in Sydney, Australia. J Sex Med. 2009;6:2311–20.

28. Prestage G, Grierson J, Bradle y J, Hurley M, Hudson J. The role of drugs during group sex among gay men in Australia. Sex Health. 2009;6:310–7.

29. Mimiaga MJ, Reisner SL, Bland SE, Driscoll MA, Cranston K, Isenberg D, et al. Sex parties among urban MSM: an emerging culture and HIV risk environment. AIDS Behav. 2011;15:305–18.

30. Crosby GM, Stall RD, Paul JP, Barrett DC. Condom use among gay/bisexual male substance abusers using the timeline follow-back method. Addict Behav. 1996;21:249–57.

31. Drumright LN, Patterson TL, Strathdee SA. Club drugs as causal risk factors for HIV acquisition among men who have sex with men: a review. Subst Use Misuse. 2006;41:1551–601.

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