



Changes in HIV Testing Utilization Among Chinese Men Who Have Sex With Men During the COVID-19 Pandemic in Shenzhen, China: An Observational Prospective Cohort Study

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Background: The Coronavirus Diseases 2019 (COVID-19) directly affects HIV prevention and sexual health services utilization among men who have sex with men (MSM). This study investigated changes in human immunodeficiency virus (HIV) testing utilization among MSM before and after the COVID-19 pandemic received initial control in Shenzhen, China.

Methods: This study was a sub-analysis of a prospective observational cohort study conducted among MSM in Shenzhen, China between August 2020 and May 2021. Participants were recruited through outreaching in gay venues, online recruitment, and peer referral. Participants completed a baseline online survey between August and September 2020 and a follow-up online survey between April and May 2021. This study was based on 412 MSM who reported to be HIV-negative/unknown sero-status at baseline, 297 (72.1%) of them completed the follow-up online survey. Multilevel logistic regression models (level 1: sources of recruitment; level 2: individual participants) were fitted.

Results: When comparing follow-up data with baseline data, a significant increase was observed in the uptake of any type of HIV testing (77.9% at Month 6 vs. 59.2% at baseline, $p < 0.001$). After adjusting for age group, education level, current employment status and monthly personal income, two predisposing factors were associated with higher uptake of HIV testing during the follow-up period. They were: (1) condomless anal intercourse with male non-regular male sex partners at follow-up only (AOR: 5.29, 95%CI: 1.27, 22.01) and (2) sanitizing before and after sex at baseline (AOR: 1.26, 95%CI: 1.02, 1.47). Regarding enabling factors, utilization of HIV testing (AOR: 3.90, 95%CI: 2.27, 6.69) and STI testing (AOR: 2.43, 95%CI: 1.20, 4.93) 6 months prior to the baseline survey was associated with higher uptake of HIV testing during the follow-up period. Having the experience that HIV testing service providers reduced service hours during

the follow-up period was also positively associated with the dependent variable (AOR: 3.45, 95%CI: 1.26, 9.41).

Conclusions: HIV testing utilization among MSM might rebound to the level before the COVID-19 outbreak after the pandemic received initial control in China. This study offered a comprehensive overview to identify potential reasons that can influence the uptake of HIV testing among Chinese MSM.

Keywords: HIV testing utilization, men who have sex with men, COVID-19, observational prospective cohort study, predictors, China

INTRODUCTION

The human immunodeficiency virus (HIV) epidemic among men who have sex with men (MSM) remains out of control across countries (1). A systematic review showed an overall HIV prevalence of 5.7% among MSM in China (1), whereas the HIV incidence in this group was 5.6 per 100 person-year (2). High coverage of HIV testing (i.e., >90%) among the at-risk population is the first and crucial step to achieve the 90-90-90 targets established by the Joint United Nations Programme on HIV/AIDS, which sheds the hope of ending the global HIV epidemic in 2030 (3). International health authorities recommend MSM take up HIV testing every 6 months (4, 5). However, HIV testing coverage remained low among MSM in China, as only 60% of Chinese MSM received any type of HIV testing in the past year (6).

The Coronavirus Diseases 2019 (COVID-19) is a serious health threat worldwide (7). The COVID-19 pandemic and its control measures (i.e., lockdown, physical distancing, and closure of business) had direct impacts on HIV prevention and sexual health services for MSM. In Japan, the number of HIV tests performed by public health centers significantly declined in the second quarter of 2020 (9,584 vs. 35,908 in the year-before period) (8). A similar situation was observed in Melbourne, Australia, where the number of HIV testing decreased from 16,367 in 2019 to 11,270 in 2020 with a 31% reduction (9). An online survey of a global sample of MSM showed that only 30 and 19% of participants had similar levels of access to facility-based HIV testing and HIV self-testing during the pandemic compared to their situation in 2019 (10). In the United States, 18.8% of MSM decreased access to HIV testing and 5.6% had trouble of getting HIV testing after the COVID-19 outbreak (11). Two cross-sectional studies investigated the impact of COVID-19 on HIV testing service utilization among Chinese MSM (12, 13). During the pandemic, 56.8% of Chinese MSM had trouble of accessing HIV testing services (12). As compared to the time before COVID-19, the utilization of facility-based HIV testing declined but the use of HIV self-testing increased (13). In China, the government implemented a lockdown in Wuhan city from January 23 to April 8, 2020. Although there was no lockdown, most Chinese cities including Shenzhen started to implement strict control measures such as the closure of non-emergency health services and non-essential business activities by the end of January 2020. Starting from May 2020, Shenzhen and most parts of China gradually relieved the control measures and

resumed non-emergency health services. These services resumed to normal around July 2020 in Shenzhen. Therefore, as parts of non-emergency health services, HIV testing and other sexual health services for MSM were mostly affected by the COVID-19 control measures between January and May 2020. At the time of our baseline survey (August to September 2020), the COVID-19 pandemic in China received initial control. MSM may increase sexual activities after COVID-19 control measures were relaxed. It is hence important to know whether the HIV testing service utilization would rebound once the COVID-19 epidemic was under control.

It is also helpful to understand factors associated with HIV testing utilization in the “post-pandemic era.” The Predisposing, Reinforcing and Enabling Constructs in Educational/Ecological Diagnosis and Evaluation (PRECEDE) model was used as the theoretical framework (14). This model posits that health behaviors (i.e., utilization of HIV testing) are influenced by predisposing factors (characteristics that motivate behavior, such as perceptions and other psychosocial variables), enabling factors (characteristics that facilitate or hinder the performance of a behavior), and reinforcing factors (rewards and punishments). Regarding predisposing factors, the COVID-19 pandemic increased some perceived barriers to use HIV testing, such as the fear of going to hospitals because of COVID-19, concerns about COVID-19 infection or having close contact with COVID-19 patients during HIV testing, and perceptions that health workers were reluctant to serve them during the pandemic (8, 15–18). Moreover, the presence of sexual risk behaviors was a strong predictor of HIV testing utilization among MSM (19, 20). An increase in sexual risk behaviors after the pandemic was under control might motivate them to take up HIV testing. Regarding enabling factors, we considered access to other health services and barriers to use HIV testing caused by COVID-19 and its control measures (i.e., suspension of testing services, history of COVID-19 infection, and centralized/home quarantine). Closure of facilities providing HIV testing services, shortage of medical staff providing HIV testing, suspension of public transportation, and lockdown/travel restrictions were barriers to access HIV testing services during the pandemic (8, 15–18). Regarding reinforcing factors, Chinese MSM tend to have large and dense social networks, and most of them are heavily involved in the community and have strong ties to each other (21). Social norms are social attitudes of approval or disapproval that are specific to what should be or should not be done in the context of health. Perceived social norm supporting HIV testing was a facilitator for

MSM to take up HIV testing (22). MSM may value the opinions of their male sex partners or peers. Therefore, being suggested not to take up HIV testing during the pandemic by male partners or peers would hinder MSM to receive such service.

To address the knowledge gaps, we conducted a longitudinal observational study to investigate the changes in HIV testing service utilization among MSM during the COVID-19 pandemic. We also investigated factors associated with HIV testing utilization during the follow-up period, including socio-demographics, predisposing factors (change in sexual behaviors, perceptions, and psychosocial variables), enabling factors (access to other health services and reinforcing factors (the suggestions made by male sex partners or peers)).

METHODS

Study Design

This study was a sub-analysis of a prospective observational cohort study conducted among MSM in Shenzhen, China between August 2020 and May 2021. Participants completed a baseline survey between August and September 2020 and a follow-up survey between April and May 2021.

Participants and Data Collection

Participants of the cohort study were: (1) Chinese-speaking men living in Shenzhen, (2) aged 18 years or above, (3) had oral or anal intercourse with at least one man in the past year, and (4) willing to leave contact information and complete the follow-up survey. We recruited participants through multiple sources. Trained and experienced fieldworkers approached prospective participants in venues frequently visited by MSM (i.e., bars, parks, and bathhouses) at different time slots during weekdays and weekends. An online outreach was also conducted by periodically posting study information on two commonly used social media platforms in China (Weibo and the official WeChat account). Recruitment was supplemented by peer referrals. On-site or through telephone/live chat applications, fieldworkers briefed prospective participants about the study details and invited them to add the project's official WeChat account. Fieldworkers screened the eligibility of prospective participants and assured participants that their identifiable information (e.g., their WeChat account) would be kept confidential, they had the right to discontinue participation in the study at any time, and their refusal or withdrawal from the study would not have any consequences. The project's official WeChat account would delink with participants' WeChat accounts after the project ended. Participants signed an electronic consent form sent by WeChat. Participants were also informed that their electronic consent form would be separated from the database and stored in a password-protected computer. The same approach to protect participants' personal information was used in a published study (23).

We developed an online self-administered questionnaire using Questionnaire Star, a commonly used online survey platform in China. Quick response codes were generated and sent to consented participants through WeChat. Participants scanned the quick response codes to complete the survey. Each mobile

device was only allowed to access the online questionnaire once to avoid duplicate responses. The baseline survey had 105 items (about 20 items per page for five pages), which took about 20 min to complete. The follow-up survey was shorter (80 items), which took about 15 min to complete. We assigned a unique study ID to each participant to link their baseline and follow-up data. The Questionnaire Star tool performed completeness checks before the questionnaire was submitted. Participants were able to review and change their responses through a "Back" button. An electronic coupon of 20 Chinese Yuan (the US \$3.0) was sent to participants upon completion of each survey. All data was stored in the online server of Questionnaire Star and protected by a password. Only the principal investigator of the study had access to the database. The fieldworkers approached 460 prospective participants in gay venues, 435 added the project's official WeChat account, 405 were screened eligible through WeChat, 135 refused to participate and 270 completed the baseline survey. Regarding online recruitment, 97 prospective participants contacted the fieldworkers, 85 were screened to be eligible, 18 refused to participate and 67 completed the baseline survey. Among 122 prospective participants referred by peers, 110 were screened to be eligible, 27 refused to participate and 83 completed the baseline survey. In sum, 420 participants completed the baseline survey. We excluded eight participants who self-reported to be HIV-positive at the baseline as this study focused on the changes in HIV testing behaviors. This study was based on 412 participants who self-reported to be HIV-negative/unknown sero-status at baseline (venue: $n = 265$, online: $n = 67$, and referral: $n = 80$). A flowchart of recruitment was shown in **Figure 1**. At Month 6, 297 (72.1%) participants completed the follow-up survey. Ethics approval was obtained from the Longhua District Center for Disease Control and Prevention (CDC) (reference: 2021009).

Measures

Design of the Questionnaire

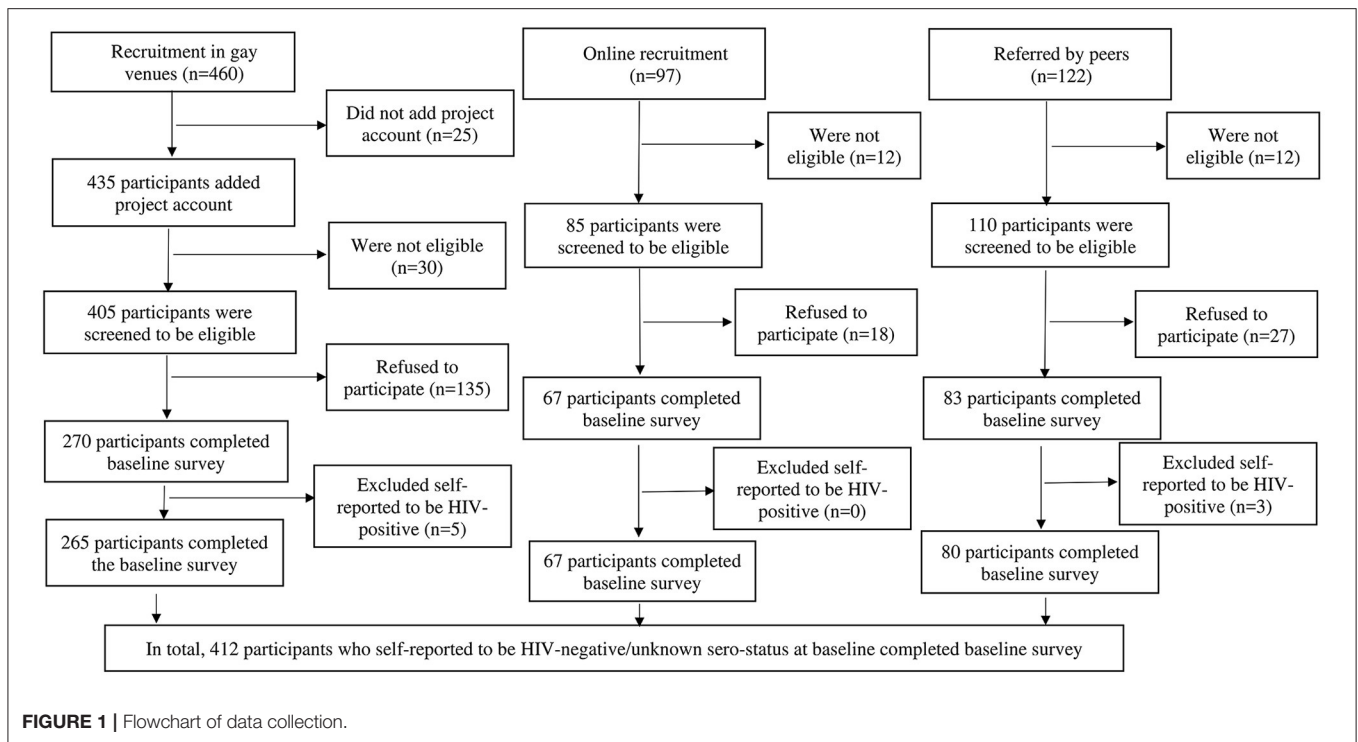
The questionnaire was developed by a panel that included a public health researcher, an epidemiologist, a psychologist, a member of the MSM community, and a member of a community-based organization. The questionnaire was tested among 10 local MSM. These 10 MSM did not participate in the cohort. Based on their feedback the questionnaire was finalized by the panel.

Sociodemographic Characteristics

At baseline, participants were asked to report on sociodemographic characteristics, including age, current relationship status, highest education level attained, current employment status, monthly personal income, and sexual orientation.

Utilization of HIV Testing Services

Utilization of the following types of HIV testing in the past 6 months was recorded at both baseline and follow-up surveys, including: (1) HIV testing at community-based organizations in Shenzhen, (2) HIV testing at public hospitals or CDC in Shenzhen, (3) HIV testing at private hospitals in Shenzhen,



(4) HIV testing at other organizations in Shenzhen, (5) HIV testing outside Shenzhen, and (6) home-based HIV self-testing. These measurements were adapted from previous studies among Chinese MSM (21, 24, 25).

Predisposing Factors

Participants reported the presence of condomless anal intercourse with regular male sex partners, non-regular male sex partners, and male sex workers, and sexualized drug use in the last 6 months prior to the baseline and follow-up surveys. Regular male sex partners were defined as their lovers or stable boyfriends, while non-regular male sex partners were defined as casual sex partners. Sexualized drug use was defined as the use of any of the following psychoactive substances [i.e., ketamine, methamphetamine, cocaine, cannabis, ecstasy, Dormicum/Halcion/Erimin 5/non-prescription hypnotic drugs, heroin, codeine from cough suppressants, amyl nitrates (poppers), γ -hydroxybutyrate (G water), and Foxy] before or during sexual intercourse (19, 26). The measurements of these sexual risk behaviors were also adapted from previous studies targeting Chinese MSM (27–29). Four variables were created by comparing the presence of such behaviors at follow-up vs. baseline (response categories: 1 = no such behavior either at baseline or follow-up, 2 = with such behavior at baseline only, 3 = with such behavior both at baseline and follow-up, and 4 = with such behavior at follow-up only).

Participants also reported the frequency of using COVID-19 preventive measures during sexual behaviors 6 months prior to the baseline survey (response categories: 1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = always). These preventive measures

were: (1) only having sex with your partner who has had sex with you before, (2) avoiding group sex, (3) only having sex at home, (4) asking your partner if they have COVID-19 symptoms, (5) avoiding kissing during sex, (6) washing hands before and after sex, and (7) sanitizing before and after sex.

At baseline, participants were also asked whether they were concerned about being infected with COVID-19 when taking up HIV testing (response categories: from 1 = strongly disagree to 5 = strongly agree). Two single items measured the perceived effectiveness of COVID-19 control measures taken by organizations providing HIV testing was measured (response categories: from 1 = not effective at all to 5 = very effective) and the level of panic of COVID-19 (response categories: from 1 = not at all to 5 = very high).

Enabling Factors

Participants reported the utilization of sexually transmitted infections (STI) testing, pre-exposure prophylaxis, and other HIV/STI prevention services 6 months prior to the baseline and follow-up surveys. Experiences about HIV testing service providers suspending their services or reducing service hours, difficulty in obtaining HIV self-testing kits, history of home/centralized quarantine, and avoiding unnecessary travel or going to crowded places were recorded at follow-up.

Reinforcing Factors

At follow-up, participants were asked whether their male sex partners or peers suggested them not take up HIV testing in the past 6 months.

Statistical Analysis

Baseline characteristics of participants who completed the follow-up survey and those who were loss-to-follow-up were compared using chi-square tests (for categorical variables) or independent sample *t*-tests (for continuous variables). We filled the missing outcome values at Month 6 with multiple imputations. Markov Chain Monte Carlo methods were used for data with the arbitrary pattern of missing values, while Monotone methods were used for data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline values of the variables with missing values at Month 6. Utilization of any type and specific type of HIV testing and sexual behaviors at baseline and follow-up were compared using McNemar tests. Using uptake of any type of HIV testing during the follow-up period as the dependent variable, and sociodemographic characteristics as independent variables, crude odds ratios (OR) were obtained using multilevel logistic regression models (level 1: sources for recruitment; level 2: individual participants). After adjusting for background characteristics in univariate analysis, the associations between independent variables of interest (predisposing, enabling, and reinforcing factors) and the dependent variable were investigated by using multivariate multilevel logistic regression models (level 1: sources for recruitment; level 2: individual participants). Random intercept models were used to allow the intercept of the regression model to vary across sources for recruitment, which could account for intra-correlated nested data. Each multivariate multilevel logistic regression model involved one of the independent variables of interest and age group, education level, current employment status, and monthly personal income. In the literature, age, education level, occupation, and monthly income were associated with HIV testing uptake among Chinese MSM (6, 24, 30, 31). Adjusted odds ratios (AOR) were obtained. Multilevel logistic/linear regression models are commonly used in studies with cluster sampling methods (32–34). SPSS 26.0 (Chicago, IL, USA) was used for data analysis, and $p < 0.05$ was considered statistically significant.

RESULTS

Baseline and Follow-Up Characteristics of Participants

The majority of the participants were aged 18–30 years (76.5%), currently single (80.4%), received tertiary education (60.9%), full-time employed (70.6%), and self-identified as homosexual (71.6%). Significant differences were found in the following baseline characteristics between those who completed the follow-up survey ($n = 297$) and those who were loss-to-follow-up ($n = 115$). These baseline characteristics were: (1) sexual orientation ($p < 0.001$), (2) performed HIV testing outside Shenzhen ($p = 0.03$), (3) uptake of any type of HIV testing ($p = 0.02$), (4) COVID-19 preventive measures during sexual behaviors ($p = 0.001$ to 0.009), and (5) perceived effectiveness of COVID-19 control measures taken by organizations providing HIV testing ($p = 0.02$) (Table 1).

Utilization of HIV Testing at Baseline and Follow-Up Surveys

When comparing follow-up data with baseline data, a significant increase was observed in the uptake of any type of HIV testing (77.9% at Month 6 vs. 59.2% at baseline, $p < 0.001$), HIV testing at community-based organizations in Shenzhen (51.6% at Month 6 vs. 11.4% at baseline, $p < 0.001$), and HIV testing at public hospitals/CDC in Shenzhen (35.2% at Month 6 vs. 20.6% at baseline, $p < 0.001$) (Table 3).

Changes in Sexual Behavior at Baseline and Follow-Up Surveys

As compared to baseline, more participants engaged in condomless anal intercourse with regular male sex partners (34.5% at Month 6 vs. 24.0% at baseline, $p = 0.002$) and male sex workers (12.9% at Month 6 vs. 2.4% at baseline, $p < 0.001$), and sexualized drug use (21.6% at Month 6 vs. 12.1% at baseline, $p = 0.001$) at Month 6. Within individuals, 19.4, 11.0, and 4.3% increased condomless anal intercourse with regular male sex partners, non-regular male sex partners, and male sex workers over the study period, and 14.0% increased sexualized drug use (Tables 2, 3).

Factors Associated With Uptake of any Type of HIV Testing During the Follow-Up Period

In univariate analysis, current employment status and monthly personal income were associated with uptake of any type of HIV testing during the follow-up period (Table 4).

After adjusting for age group, education level, current employment status, and monthly personal income, two predisposing factors were associated with higher uptake of HIV testing during the follow-up period. They were: (1) condomless anal intercourse with male non-regular male sex partners at follow-up only (AOR: 5.29, 95%CI: 1.27, 22.01) and (2) sanitizing before and after sex at baseline (AOR: 1.26, 95%CI: 1.02, 1.47). Regarding enabling factors, utilization of HIV testing (AOR: 3.90, 95%CI: 2.27, 6.69) and STI testing (AOR: 2.43, 95%CI: 1.20, 4.93) 6 months prior to the baseline survey was associated with higher uptake of HIV testing during the follow-up period. Having the experience that HIV testing service providers reduced service hours during the follow-up period was also positively associated with the dependent variable (AOR: 3.45, 95%CI: 1.26, 9.41) (Table 5).

DISCUSSION

To our knowledge, this is one of the first prospective cohort studies to investigate the changes in HIV testing utilization among MSM before and after the COVID-19 pandemic received initial control. As compared to baseline data, significant increases in the uptake of any type of HIV testing, facility-based HIV testing (e.g., those performed at community-based organizations, public and private hospitals), and HIV self-testing were observed at follow-up. COVID-19 preventive measures during sexual behaviors and HIV-related service utilization at baseline and

TABLE 1 | Baseline characteristics of participants.

	All participants (n = 412)	Follow-up at Month 9 (n = 297)	Loss to follow-up (n = 115)	P-values
	n (%)	n (%)	n (%)	
Sociodemographic				
Age group (years)				
18–24	130 (31.6)	87 (29.3)	43 (37.4)	0.18
25–30	185 (44.9)	139 (46.8)	46 (40.0)	
31–40	74 (18.0)	57 (19.2)	17 (14.8)	
>40	23 (5.5)	14 (4.7)	9 (7.8)	
Current relationship status				
Currently single	331 (80.4)	234 (78.8)	97 (84.3)	0.41
Married or cohabited with a man	66 (16.0)	52 (17.5)	14 (12.2)	
Married or cohabited with a woman	15 (3.6)	11 (3.7)	4 (3.5)	
Highest education level attained				
Junior high or below	52 (12.6)	35 (11.8)	17 (14.8)	0.15
Senior high or equivalent	93 (22.6)	60 (20.2)	33 (28.7)	
College or above	251 (60.9)	191 (64.3)	60 (52.2)	
Others	16 (3.9)	11 (3.7)	5 (4.3)	
Current employment status				
Full-time	291 (70.6)	216 (72.7)	75 (65.2)	0.13
Part-time/unemployed/retired/students/others	121 (29.4)	81 (27.3)	40 (34.8)	
Monthly personal income, Chinese Yuan (US dollar)				
No fixed income	38 (9.2)	27 (9.1)	11 (9.6)	0.12
Below 3,000 (461.4)	33 (8.0)	22 (7.4)	11 (9.6)	
3,000–4,999 (461.4–768.9)	91 (22.2)	61 (20.5)	30 (26.1)	
5,000–6,999 (769.1–1076.5)	86 (20.9)	56 (18.9)	30 (26.1)	
7,000–9,999 (1076.7–1537.9)	69 (16.7)	57 (19.2)	12 (10.4)	
10,000 or above (1538.1)	76 (18.4)	61 (20.5)	15 (13.0)	
Refuse to disclose	19 (4.6)	13 (4.4)	6 (5.2)	
Sexual orientation				
Homosexual	295 (71.6)	233 (78.5)	62 (53.9)	<0.001
Bisexual	83 (20.1)	51 (17.2)	32 (27.8)	
Heterosexual	14 (3.4)	3 (1.0)	11 (9.6)	
Uncertain	20 (4.9)	10 (3.3)	10 (8.7)	
Recruitment sources				
Outreaching in gay venues	265 (64.3)	190 (64.0)	75 (65.2)	0.93
Online recruitment	67 (16.3)	48 (16.2)	19 (16.5)	
Peer referral	80 (19.4)	59 (19.9)	21 (18.3)	
Predisposing factors				
Sexual behaviors in the past 6 months (February to July 2020), n (%), Yes				
Condomless anal intercourse with regular male sex partners	99 (24.0)	73 (24.6)	26 (22.6)	0.68
Condomless anal intercourse with non-regular male sex partners	51 (12.4)	38 (12.8)	13 (11.3)	0.68
Condomless anal intercourse with male sex workers	10 (2.4)	5 (1.7)	5 (4.3)	0.15
Sexualized drug use	50 (12.1)	38 (12.8)	12 (10.4)	0.51
COVID-19 preventive measures during sexual behaviors (February to July 2020), n (%) always/often				
Only having sex with my partner who has had sex with me before	138 (33.5)	111 (37.4)	27 (23.5)	0.007
Avoiding group sex	170 (41.3)	136 (45.8)	34 (29.6)	0.003

(Continued)

TABLE 1 | Continued

	All participants (n = 412)	Follow-up at Month 9 (n = 297)	Loss to follow-up (n = 115)	P-values
	n (%)	n (%)	n (%)	
Only having sex at home	170 (41.3)	135 (45.5)	35 (30.4)	0.005
Asking your partner if they have COVID-19 symptoms	109 (26.5)	89 (30.0)	20 (17.4)	0.009
Avoiding kissing during sex	103 (25.0)	85 (28.6)	18 (15.7)	0.006
Washing hands before and after sex	247 (60.0)	193 (65.0)	54 (47.0)	0.001
Sanitizing before and after sex	170 (41.3)	136 (45.8)	34 (29.6)	0.003
Psychosocial variables related to COVID-19 and HIV testing				
Worry about being infected with COVID-19 when undertaking HIV testing, n (%) strongly agree/agree	162 (39.3)	118 (39.7)	44 (38.3)	0.78
Mean (SD)	3.2 (1.3)	3.3 (1.3)	3.0 (1.4)	0.06
Perceived effectiveness of COVID-19 control measures taken by organizations providing HIV testing, n (%) very effective/relatively effective	235 (57.0)	177 (59.6)	58 (50.4)	0.09
Mean (SD)	3.5 (1.1)	3.6 (1.1)	3.3 (1.2)	0.02
Level of panic of COVID-19 infections, n (%) very high/relatively high	135 (32.8)	100 (33.7)	35 (30.4)	0.53
Mean (SD)	3.1 (1.1)	3.1 (1.0)	3.0 (1.2)	0.37
Enabling factors				
Use of different types of HIV testing in the past 6 months (February to July 2020), n (%) Yes				
HIV testing at community-based organization in Shenzhen	47 (11.4)	38 (12.8)	9 (7.8)	0.16
HIV testing at public hospitals or CDC in Shenzhen	85 (20.6)	62 (20.9)	23 (20.0)	0.84
HIV testing at private hospitals in Shenzhen	20 (4.9)	17 (5.7)	3 (2.6)	0.19
HIV testing at other organizations in Shenzhen	38 (9.2)	28 (9.4)	10 (8.7)	0.82
HIV testing outside Shenzhen	74 (18.0)	61 (20.5)	13 (11.3)	0.03
Home-based HIV self-testing	176 (42.7)	134 (45.1)	42 (36.5)	0.11
Any type of HIV testing	244 (59.2)	186 (62.6)	58 (50.4)	0.02
Utilization of other HIV/STI prevention services in the past 6 months (February to July 2020), n (%), Yes				
Testing for STI	101 (24.5)	78 (26.3)	23 (20.0)	0.19
Other HIV/STI prevention services ^a	151 (36.7)	114 (38.4)	37 (32.2)	0.24
Pre-exposure prophylaxis	28 (6.8)	20 (6.7)	8 (7.0)	0.94

^a Other HIV/STI prevention services: condom distribution, peer education, HIV/STI promotion leaflets and lectures, and HIV/STI prevention knowledge via the Internet or social media. The bold values indicate the values of $p < 0.05$ which are statistically significant.

changes in sexual behaviors and barriers caused by COVID-19 and its control measures over the study period were associated with HIV testing uptake during the follow-up period. The use of the PRECEDE model provided a more comprehensive overview of factors influencing HIV testing uptake and expanded the application of such a model.

About 60% of the sampled MSM used any type of HIV testing between February and July 2020. Such uptake rate was slightly lower than the level before the COVID-19 outbreak (about

70%) (35, 36). Our findings were in line with previous studies investigating the potential impact of COVID-19 on HIV testing service utilization in China (12, 13). However, the magnitude of such impact might be smaller than that of other countries (8–11). In line with our hypothesis, HIV testing uptake had rebounded after the COVID-19 received control. A significant increase in the uptake of any type of HIV testing was observed during the study period. At follow-up, 77.9% of participants received any type of HIV testing in the past 6 months. Such uptake rate was similar

TABLE 2 | Barriers to take up HIV testing caused by COVID-19 and its control measures and changes in sexual behaviors ($n = 412$).

	% ^a
Predisposing factors	
Condomless anal intercourse with regular male sex partners	
With such behavior at baseline only	9.0
No such behavior either at baseline or follow-up	56.6
With such behavior both at baseline and follow-up	15.0
With such behavior at follow-up only	19.4
Condomless anal intercourse with non-regular male sex partners	
With such behavior at baseline only	7.0
No such behavior either at baseline or follow-up	76.7
With such behavior both at baseline and follow-up	5.3
With such behavior at follow-up only	11.0
Condomless anal intercourse with male sex workers	
With such behavior at baseline only	2.0
No such behavior either at baseline or follow-up	93.2
With such behavior both at baseline and follow-up	0.5
With such behavior at follow-up only	4.3
Sexualized drug use	
With such behavior at baseline only	4.6
No such behavior either at baseline or follow-up	73.8
With such behavior both at baseline and follow-up	7.5
With such behavior at follow-up only	14.0
Enabling factors	
Barriers to take up HIV testing caused by COVID-19 and its control measures during the follow-up period, % Yes	
HIV testing service providers suspended their services	12.4
HIV testing service providers reduced their service hours	14.3
Difficult to obtain HIV self-testing kits	10.4
History of home/centralized quarantine	12.6
You avoided unnecessary travel and tried to stay at home	54.6
You avoided going to crowded places	60.9
Reinforcing factors	
Your male sex partners or friends suggested you not to take up HIV testing	16.5

^a Multiple imputation was performed to replace missing values at Month 6. Markov chain Monte Carlo methods were used for data with an arbitrary pattern of missing values, while Monotone methods were used for data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline value of the variable with missing values at Month 6.

to that observed in the time before the COVID-19 outbreak in China (35, 36).

The changes in the utilization of specific types of HIV testing provided a more comprehensive picture of the impacts of the COVID-19 pandemic. Before the COVID-19 outbreak, community-based organizations, public hospitals, and CDC provided over 80% of HIV testing services for MSM, while private hospitals and other organizations provided almost 30% of HIV testing services for them (37). Our findings suggested that HIV testing services provided by these organizations were most affected by the COVID-19 pandemic and its control measures in China, as only 11.4, 20.6, 4.9, and 9.2% of our participants used facility-based HIV testing at community-based

TABLE 3 | Comparing HIV testing behaviors and sexual behaviors in the past 6 months measured at baseline and follow-up ($n = 412$).

	Baseline	Follow-up ^a	P-values
	% Yes	% Yes	
Sexual behaviors			
Condomless anal intercourse with regular male sex partners	24.0	34.5	0.002
Condomless anal intercourse with non-regular male sex partners	12.4	16.2	0.34
Condomless anal intercourse with male sex workers	2.4	12.9	<0.001
Sexualized drug use	12.1	21.6	0.001
Utilization of HIV prevention services			
HIV testing at community-based organization in Shenzhen	11.4	51.6	<0.001
HIV testing at public hospitals or CDC in Shenzhen	20.6	35.2	<0.001
HIV testing at private hospitals in Shenzhen	4.9	13.1	<0.001
HIV testing at other organizations in Shenzhen	9.2	17.2	0.01
HIV testing outside Shenzhen	18.0	23.3	0.16
Home-based HIV self-testing	42.7	52.4	0.001
Any type of HIV testing	59.2	77.9	<0.001

^a Multiple imputation was performed to replace missing values at Month 6. Markov chain Monte Carlo methods were used for data with an arbitrary pattern of missing values, while Monotone methods were used for data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline value of the variable with missing values at Month 6. The bold values indicate the values of $p < 0.05$ which are statistically significant.

organizations, public hospitals/CDC, private hospitals and other organizations between February and July 2020, respectively. Before the COVID-19 pandemic received initial control, MSM in China mainly relied on home-based HIV self-testing. The utilization of HIV self-testing during February and July 2020 (42.7%) was higher than that observed in the pre-pandemic period (20.3–39.7%) (38–41). Many users of the facility-based HIV testing might shift to HIV self-testing during the COVID-19 pandemic (13). Promotion and implementation of HIV self-testing among MSM have been quite successful in China, which might mitigate the negative impact of the COVID-19 pandemic on HIV testing service utilization (42). After the COVID-19 pandemic received initial control, the largest increase was observed for HIV testing at community-based organizations, followed by HIV testing at public hospitals/CDC, private hospitals, and other organizations. It was encouraging that the use of HIV self-testing also increased over time. It is possible that many MSM tried HIV self-testing for the first time during the pandemic and found it an appealing alternative option to facility-based HIV testing (13).

Our findings suggested some reasons to explain the changes in HIV testing utilization and provided some empirical implications to enhance HIV testing coverage among MSM in the “post-pandemic era.” Similar to the findings of a previous study, MSM

TABLE 4 | Associations between baseline sociodemographic and uptake of any type of HIV testing during the follow-up period ($n = 412$).

	OR (95%CI)	P-values
Sociodemographic		
Age group (years)		
18–24	1.0	
25–30	0.87 (0.51, 1.50)	0.62
31–40	1.35 (0.63, 2.89)	0.44
>40	3.07 (0.67, 13.94)	0.15
Current relationship status		
Currently single	1.0	
Married or cohabited with a man	0.64 (0.35, 1.17)	0.15
Married or cohabited with a woman	1.73 (0.38, 7.87)	0.48
Highest education level attained		
Junior high or below	1.0	
Senior high or equivalent	1.13 (0.41, 3.10)	0.82
College or above	0.42 (0.18, 1.00)	0.05
Others	0.56 (0.15, 2.83)	0.56
Current employment status		
Full-time	1.0	
Part-time/unemployed /retired/students/others	0.55 (0.33, 0.91)	0.02
Monthly personal income, Chinese Yuan (US dollar)		
No fixed income	1.0	
Below 3,000 (461.4)	1.98 (0.71, 5.47)	0.19
3,000–4,999 (461.4–768.9)	2.79 (1.02, 7.67)	0.04
5,000–6,999 (769.1–1076.5)	1.16 (0.44, 3.06)	0.77
7,000–9,999 (1076.7–1537.9)	1.25 (0.49, 3.16)	0.64
10,000 or above (1538.1)	0.88 (0.28, 2.74)	0.82
Refuse to disclose	3.68 (0.69, 19.63)	0.13
Sexual orientation		
Homosexual	1.0	
Bisexual	2.12 (0.95, 4.74)	0.07
Heterosexual	2.05 (0.45, 9.36)	0.36
Uncertain	2.55 (0.57, 11.36)	0.22
Source of recruitment		
Outreaching in venues	1.0	
Online recruitment	0.79 (0.46, 1.36)	0.40
Peer referral	1.31 (0.79, 2.17)	0.30

Multiple imputation was performed to replace missing values at Month 6. Markov chain Monte Carlo methods were used for data with an arbitrary pattern of missing values, while Monotone methods were used for data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline value of the variable with missing values at Month 6. OR: crude odds ratios obtained from two-level logistic regression models (level 1: sources of recruitment, level 2: individual participants). CI, confidence interval. The bold values indicate the values of $p < 0.05$ which are statistically significant.

without a full-time job were less likely to use HIV testing during the follow-up period (43). In addition, lower income was also a barrier to use HIV testing during the follow-up period. Future programs should pay more attention to MSM with lower socio-economic status.

Changes in condomless anal intercourse with non-regular male sex partners was a significant predisposing factor of HIV testing utilization during the follow-up period. As

compared to those without/reduced condomless anal intercourse with non-regular male sex partners during the follow-up period, an increase in condomless anal intercourse with non-regular male sex partners was associated with higher HIV testing uptake. It is possible that those with an increase in condomless anal intercourse with non-regular male sex partners would perceive a higher risk of HIV transmission, which motivated them to take up HIV testing. Although condomless anal intercourse with regular male sex partners, condomless anal intercourse with male sex workers, and sexualized drug use significantly increased over the follow-up period, such increase did not motivate them to receive HIV testing. Health communication messages that condomless anal intercourse with regular male sex partners and sexualized drug use are independent risk factors of HIV acquisition should be disseminated to MSM to increase their awareness (44, 45). Use of COVID-19 preventive measures during sexual behaviors, such as sanitizing before and after sex, was associated with higher uptake of HIV testing during the follow-up period. It is possible that MSM who adopted this preventive measure had higher motivation and self-efficacy to protect themselves (46, 47).

Utilization of HIV, STI, and other HIV/STI prevention services prior to the baseline survey was associated with higher uptake of HIV testing during the follow-up period. Previous studies suggested that frequent users of HIV testing were more likely to take up HIV testing again (48, 49). MSM who had utilized STI testing and other HIV/STI prevention services might be more familiar with the service providers and hence had a higher level of trust (50). The trust of service providers was a facilitator of receiving HIV testing (51). In contrast to our hypothesis, the exposure to HIV testing services with reduced service hours was positively associated with the outcome. One possible explanation is that those who were proactively seeking HIV testing would know about the changes in HIV testing service hours, while those who did not seek might be less likely to know about it.

Our study has some policy and program implications. After the control of the COVID-19 pandemic, MSM would increase sexual activities and hence have a stronger need for HIV testing. Therefore, local government and service providers should resume their workforce and working hours for HIV prevention services. Our findings also suggested that facility-based HIV testing services were most affected during the COVID-19 outbreak. Local service providers should consider promoting home-based HIV self-testing and relevant supporting services (e.g., online counseling support and referral services for HIV self-testing users) to mitigate the negative impact caused by the COVID-19 pandemic.

This study had a number of limitations. First, participants were recruited by non-probability sampling in the absence of a sampling frame. The findings may not be representative of MSM in Shenzhen. Since we only conducted the study in one Chinese city, caution should be taken when generalizing the findings to other parts of China. As compared to other less developed cities in China, more organizations are providing HIV testing services for MSM in Shenzhen. Moreover, given

TABLE 5 | Factors associated with uptake of any type of HIV testing during the follow-up period (among participants who completed both surveys, $n = 297$).

	OR (95%CI)	P-values	AOR (95%CI)	P-values
Predisposing factors				
Condomless anal intercourse with regular male sex partners				
No such experience either at baseline or follow-up/With such experience at baseline only	1.0		1.0	
With such experience both at baseline and follow-up	1.36 (0.62, 2.99)	0.44	1.43 (0.63, 3.24)	0.38
With such experience at follow-up only	1.77 (0.81, 3.84)	0.15	1.73 (0.71, 4.27)	0.22
Condomless anal intercourse with non-regular male sex partners				
No such experience either at baseline or follow-up/With such experience at baseline only	1.0		1.0	
With such experience both at baseline and follow-up	3.05 (0.62, 14.90)	0.17	2.72 (0.56, 13.09)	0.21
With such experience at follow-up only	3.96 (1.18, 13.38)	0.03	5.29 (1.27, 22.01)	0.02
Condomless anal intercourse with male sex workers				
No such experience either at baseline or follow-up/With such experience at baseline only	1.0		1.0	
With such experience both at baseline and follow-up	0.29 (0.02, 4.68)	0.38	0.16 (0.01, 2.89)	0.22
With such experience at follow-up only	2.32 (0.52, 10.28)	0.27	2.15 (0.45, 10.35)	0.34
Sexualized drug use				
No such experience either at baseline or follow-up/With such experience at baseline only	1.0		1.0	
With such experience both at baseline and follow-up	2.13 (0.64, 7.05)	0.22	1.83 (0.55, 6.08)	0.32
With such experience at follow-up only	2.02 (0.85, 4.80)	0.11	2.10 (0.77, 5.74)	0.15
COVID-19 preventive measures during sexual behaviors (February to July 2020)				
Only having sex with my partner who has had sex with me before	0.92 (0.78, 1.08)	0.30	0.96 (0.80, 1.14)	0.63
Avoiding group sex	0.87 (0.76, 1.01)	0.06	0.92 (0.79, 1.06)	0.25
Only having sex at home	0.91 (0.77, 1.08)	0.28	0.94 (0.78, 1.14)	0.53
Asking your partner if they have COVID-19 symptoms	1.05 (0.89, 1.24)	0.59	1.10 (0.92, 1.31)	0.31
Avoiding kissing during sex	1.14 (0.95, 1.35)	0.16	1.12 (0.93, 1.35)	0.22
Washing hands before and after sex	1.08 (0.92, 1.26)	0.33	1.08 (0.91, 1.28)	0.41
Sanitizing before and after sex	1.18 (1.02, 1.38)	0.03	1.26 (1.02, 1.47)	0.01
Psychosocial variables related to COVID-19 and HIV testing				
Worry about being infected with COVID-19 when undertaking HIV testing	1.08 (0.90, 1.30)	0.42	1.05 (0.87, 1.28)	0.61
Perceived effectiveness of COVID-19 control measures taken by organizations providing HIV testing	1.13 (0.91, 1.41)	0.28	1.10 (0.86, 1.39)	0.44
Level of panic of COVID-19 infections	0.99 (0.78, 1.27)	0.95	0.95 (0.72, 1.25)	0.71
Enabling factors				
HIV testing in the past 6 months (February to July 2020)				
No	1.0		1.0	
Yes	3.17 (1.93, 5.20)	<0.001	3.90 (2.27, 6.69)	<0.001
Testing for STI in the past 6 months (February to July 2020)				
No	1.0		1.0	
Yes	2.13 (1.11, 4.11)	0.02	2.43 (1.20, 4.93)	0.01
Utilization of other HIV/STI prevention services in the past 6 months (February to July 2020)				
No	1.0		1.0	
Yes	1.66 (0.98, 2.82)	0.06	1.68 (0.95, 2.96)	0.07
Use of pre-exposure prophylaxis in the past 6 months (February to July 2020)				
No	1.0		1.0	
Yes	1.80 (0.50, 6.54)	0.37	2.03 (0.51, 8.08)	0.31
Barriers to take up HIV testing caused by COVID-19 and its control measures during the follow-up period				
HIV testing service providers suspended their services	2.88 (0.95, 8.73)	0.06	2.79 (0.81, 9.60)	0.10
HIV testing service providers reduced their service hours	1.95 (1.12, 7.77)	0.03	3.45 (1.26, 9.41)	0.02
Difficult to obtain HIV self-testing kits	1.64 (0.55, 4.86)	0.37	1.63 (0.55, 4.85)	0.37

(Continued)

TABLE 5 | Continued

	OR (95%CI)	P-values	AOR (95%CI)	P-values
History of home/centralized quarantine	1.59 (0.37, 6.90)	0.50	1.60 (0.33, 7.68)	0.52
You avoided unnecessary travel and tried to stay at home	0.82 (0.49, 1.39)	0.47	0.85 (0.47, 1.51)	0.57
You avoided going to crowded places	1.33 (0.81, 2.18)	0.26	1.36 (0.78, 2.37)	0.28
Reinforcing factors				
Your male sex partners or friends suggested you not to take up HIV testing	0.92 (0.22, 3.84)	0.91	1.19 (0.39, 3.68)	0.75

Multiple imputation was performed to replace missing values at Month 6. Markov chain Monte Carlo methods were used for data with an arbitrary pattern of missing values, while Monotone methods were used for data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline value of the variable with missing values at Month 6. vOR, crude odds ratios obtained from two-level logistic regression models (level 1: sources of recruitment, level 2: individual participants); AOR, adjusted odds ratios, odds ratios obtained from two-level logistic regression models (level 1: sources of recruitment, level 2: individual participants) after adjusting for age group, education level, current employment status, and monthly income level; CI, confidence interval. The bold values indicate the values of $p < 0.05$ which are statistically significant.

the higher income level, MSM in Shenzhen would have lower financial barriers to use chargeable HIV testing services provided by private clinics or to purchase HIV self-testing kits. Therefore, the findings in this article could not apply to other Chinese cities with a general or lower economy. The COVID-19 pandemic might have a greater impact on HIV testing services in other smaller or less developed Chinese cities. Second, the results were self-reported and subject to social desirability bias. Participants might over-report HIV uptake and under-report sexual risk behaviors. Third, attribution bias existed. As compared to those who were followed up, dropouts had lower utilization of HIV testing and were less likely to use COVID-19 preventive behaviors during sexual intercourse at baseline. Therefore, the prevalence of HIV testing uptake at follow-up might be overestimated. Fourth, we were not able to obtain the characteristics of participants who refused to join the study. Participants and refusals might have different characteristics. Selection bias existed. However, the response rate was relatively high as compared to other published studies in China. Finally, we did not find validated measurements based on the PRECEDE model that were applicable to HIV testing behaviors under the COVID-19 pandemic. Therefore, we self-constructed the measurements based on panel discussion involving public health researcher, epidemiologist, psychologist, local MSM, and staff of local community-based organizations.

CONCLUSIONS

As compared to the baseline data, the uptake of any type of HIV testing, facility-based HIV testing at community-based organizations, public hospitals/CDC, private hospitals, other organizations, and HIV self-testing increased significantly at follow-up. HIV testing utilization among MSM might rebound to the level before the COVID-19 outbreak after the pandemic received initial control in China. Using the PRECEDE model, this study offered a comprehensive overview to identify potential

reasons that can influence the uptake of HIV testing among Chinese MSM in the post-pandemic era.

DATA AVAILABILITY STATEMENT

The data presented in this study are available from the corresponding author upon request. The data are not publicly available as they contain sensitive personal behaviors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Boards of Longhua District Center for Disease Control and Prevention (CDC) (reference: 2021009). Informed consent was obtained from all participants involved in the study.

AUTHOR CONTRIBUTIONS

KZ and ZW: conceptualization, methodology, and supervision. KZ, HCa, HCh, TH, YC, and XZ: data curation and project administration. ZW, SC, and PC: formal analysis. ZW, SC, YF, and PC: writing-original draft preparation and writing-review and editing. All authors have read and agreed to the published version of the manuscript.

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