



# An Online Intervention Promoting HIV Testing Service Utilization Among Chinese men who have sex with men During the COVID-19 Pandemic: A quasi-experimental Study

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## Abstract

The COVID-19 pandemic created disruptions in HIV testing service utilization among men who have sex with men (MSM). The present study was to evaluate the effectiveness of an online health promotion program implemented by a community-based organization (CBO) in increasing the uptake of any type of HIV testing and home-based HIV self-testing (HIVST) over a six-month follow-up period. Participants of an observational prospective cohort study conducted during the same period served as the comparison group. This study was conducted between September 2020 and December 2021. Participants were Chinese-speaking adult MSM who were HIV-negative/unknown sero-status recruited through multiple sources in Hong Kong, China. Participants in the intervention group were exposed to the following health promotion components: (1) viewing an online video promoting HIVST, (2) visiting the project webpage, and (3) having access to a chargeable HIVST service implemented by the CBO. Among 400 and 412 participants in the intervention group and the comparison group, 349 (87.3%) and 298 (72.3%) completed follow-up evaluation at Month 6. Multiple imputation was used to replace missing values. At Month 6, participants in the intervention group reported significantly higher uptake of any type of HIV testing (57.0% versus 49.0%, adjusted odds ratios [AOR]: 1.43,  $p=.03$ ) and HIVST (25.8% versus 14.8%, AOR: 2.04,  $p=.001$ ), as compared to those in the comparison group. Process evaluation of the health promotion components for the intervention group was positive. Promoting HIVST is a potentially useful strategy to increase HIV testing service utilization among Chinese MSM during the pandemic.

**Keywords** COVID-19 · home-based HIV self-testing · health promotion · quasi-experimental study · men who have sex with men

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## Introduction

The coronavirus disease 2019 (COVID-19) has become a pandemic of international concern for almost three years. As of 9 January 2023, more than 659 million confirmed cases and over 6.7 million deaths have been recorded worldwide [1]. In the Hong Kong Special Administrative Region (SAR) of China, where this study was conducted, the cumulative number of confirmed cases was 2.8 million, while the COVID-19 associated deaths was 12,481 as of 9 January 2023 [2].

International health authorities recommend men who have sex with men (MSM) to take up HIV testing every six months [3, 4]. Nevertheless, the COVID-19 pandemic and its control measures (e.g., lockdown, physical distancing,

and closure of business) had a direct impact on HIV prevention and sexual health services for MSM. As compared to 2019, the number of HIV tests decreased significantly in 2020 in Australia and Japan [5, 6]. 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 [7]. 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 home-based HIV self-testing (HIVST) during the pandemic, as compared to their situations in 2019 [8]. China has repeatedly applied strict measures (i.e., compulsory universal COVID-19 screening, social distancing, and even lockdown), with significant and long-lasting impacts on HIV testing service utilization among Chinese MSM [9–12]. Facility-based HIV testing services were most affected [10, 12]. In the Hong Kong SAR of China, 56.8% of MSM had difficulties in accessing HIV testing services during the pandemic [11]. In response to the COVID-19 situation, facility-based HIV testing services provided by community-based organizations (CBOs) were closed or reduced between July 2020 and January 2021 [13]. During the same period, the CBOs also suspended testing services at gay saunas as these venues were temporarily closed by the government [13]. In addition, most CBOs in Hong Kong stopped all physical outreach and education programs, and mobile testing units [13]. Some governmental HIV testing facilities (e.g., social hygiene clinics) were suspended during the pandemic as the government reallocated resources to focus on COVID-19 control [14]. However, the availability of HIVST kits was not affected by the pandemic in Hong Kong.

In response to the impacts of the COVID-19 on HIV testing, the Joint United Nations Program on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) have provided guidance and placed emphasis on the importance of developing and implementing virtual/online interventions to promote HIV testing for priority groups including MSM [15]. To our knowledge, three programs were promoting HIVST among MSM during the pandemic. In the United States, a program has been distributing free HIVST kits to MSM through messages and embedded links in gay dating applications since March 2020 [16]. A survey of 1,764 MSM in the United States showed that 34% of the participants joined the program and requested HIVST kits [16]. Another program was launched in the Philippines in October 2020. MSM could order free HIVST kits online by visiting the program's Facebook page [15]. A total of 5,279 kits were ordered during the project period. Another program in Lebanon has been promoting HIVST through social media platforms and online dating applications, which distributed 625 free HIVST kits to MSM users [17]. However, these

programs were evaluated using non-experimental design without a control or comparison group.

The primary objective of the present study was to evaluate the effectiveness of an online health promotion program implemented by the CBO in increasing the uptake of any type of HIV testing and HIVST over a six-month follow-up period during the pandemic using quasi-experimental design. Participants of an observational prospective cohort study conducted during the same period served as the comparison group. The secondary objectives were to investigate the between-group difference in sexual risk behaviors (condomless anal intercourse [CAI], multiple male sex partnerships, sexualized drug use) measured at Month 6. We hypothesized that the uptake of any type of HIV testing and HIVST would be higher in the intervention group than in the comparison group during the study period.

## Methods

### Study Design

This study was conducted between September 2020 and December 2021. During the study period, an online program promoting HIVST was implemented by a CBO for MSM in Hong Kong SAR, China. Participants completed baseline telephone survey and received online intervention promoting HIVST between September 2020 and May 2021. They completed another telephone survey six months after the baseline survey. The study was registered at ClinicalTrials.gov (NCT05398835). Participants of an observational prospective cohort study investigating the impacts of COVID-19 on sexual behaviors and HIV testing service utilization among MSM in Hong Kong served as the comparison group. Participants of the observational cohort study completed two telephone surveys six months apart. The flowchart of this study was shown in Fig. 1. The COVID-19 situation and its control measures in Hong Kong during the study period was illustrated in Fig. 2.

### Participants and Recruitment

Inclusion criteria for the intervention group and the comparison group were: (1) Hong Kong Chinese-speaking males aged 18 years or above, (2) had anal intercourse with at least one man in the past year, (3) willing to leave contacts to complete a follow-up telephone survey, and (4) having access to the internet. Those who self-reported as HIV positive were excluded.

The CBO staff recruited MSM to join their online health promotion program. During the same period, another team of trained peer fieldworkers invited MSM who had not

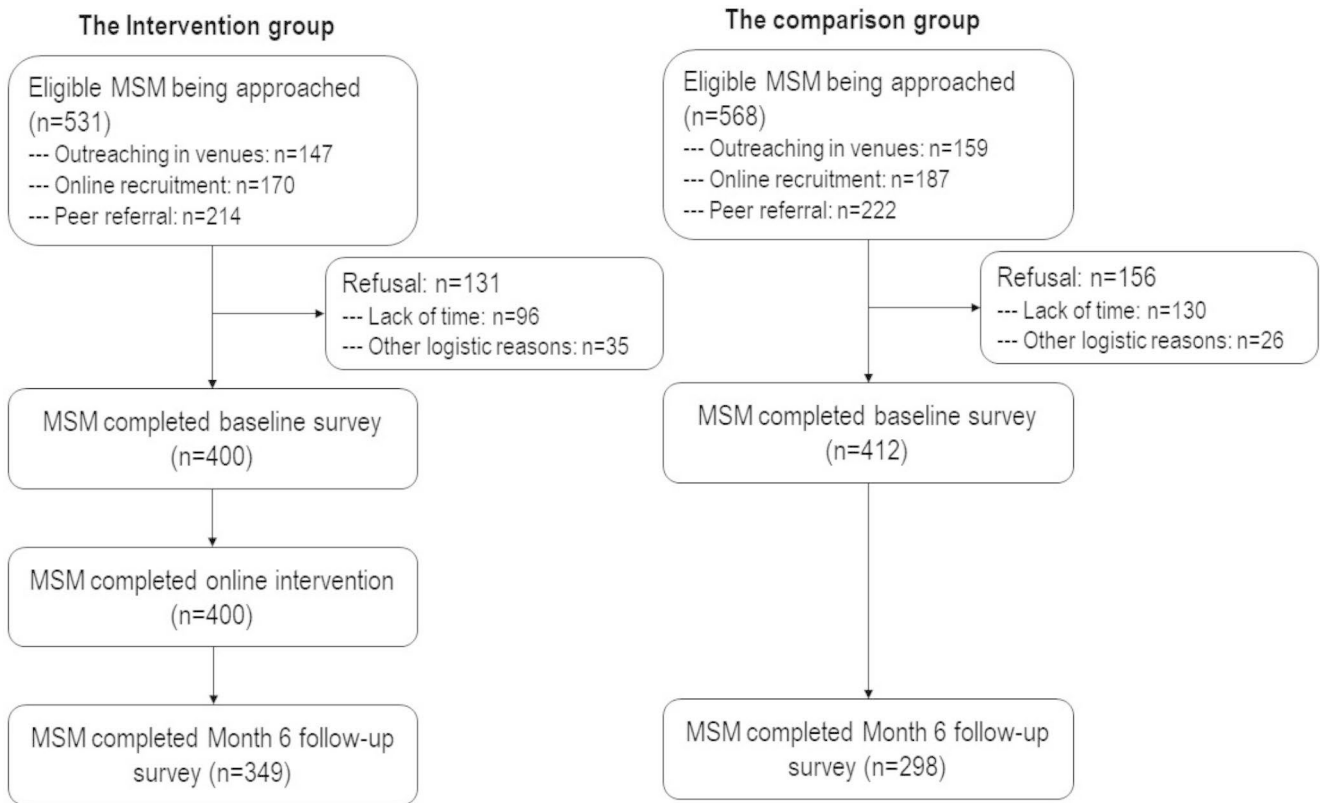


Fig. 1 Flowchart of the study

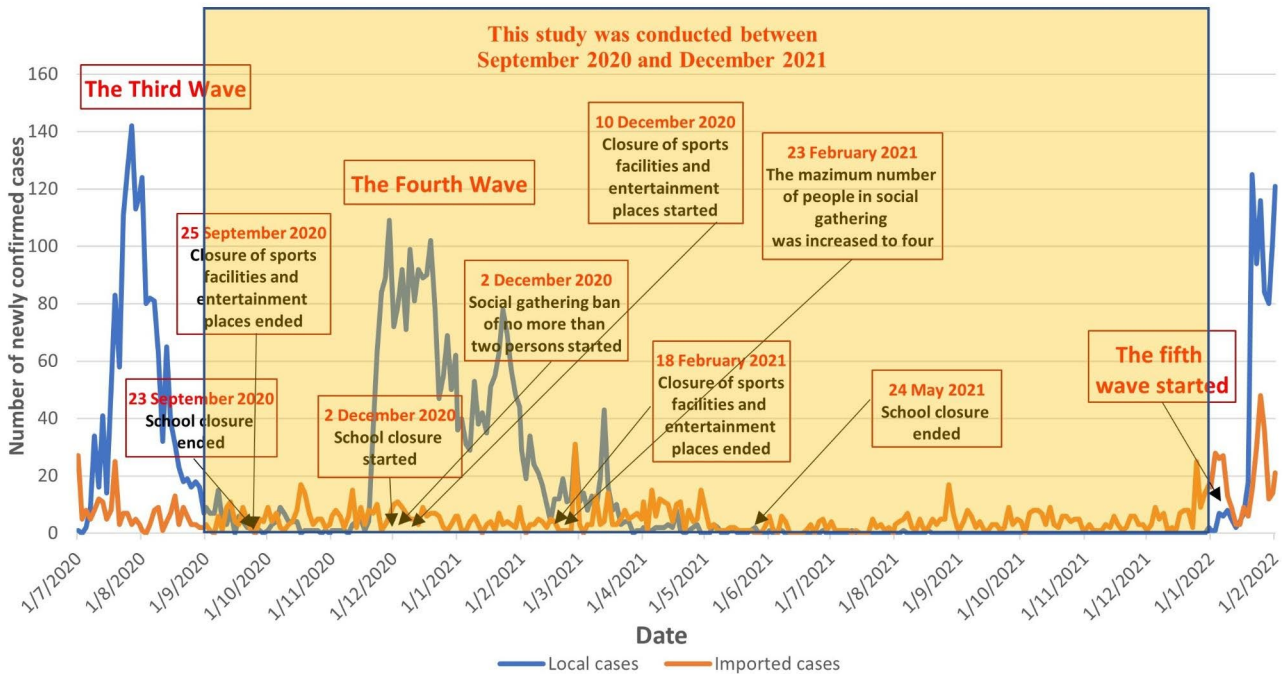


Fig. 2 COVID-19 situation during the study period

enrolled in the CBO health promotion program to join an observational prospective cohort study as comparison group. Similar approaches were used to recruit participants in both groups. Online outreach was conducted by posting study information periodically as discussion topics on two gay websites with the highest number of visitors in Hong Kong. Interested participants could contact project staff by telephone or instant messaging applications. The project staff also approached MSM in gay bars. During the recruitment period, bars in Hong Kong were ordered to close between 1 and 2020 and 1 October 2020, and between 26 and 2020 and 1 April 2021. Recruitment was supplemented by peer referral. Through telephone or instant messaging applications, participants were briefed about the study procedures and data security, informed that they had the right to terminate participation at any time, and given an information sheet explaining the details of the program. Verbal informed consent was sought. The project staff signed a form pledging that participants were fully informed about the study. Similar approaches to obtain informed consent were used in published studies [18, 19]. The pledge forms were kept separately from the questionnaires and stored in a locked cabinet. Multiple forms of contact information were obtained to make an appointment to conduct the baseline survey and online intervention. The project staff cross-checked the contact information to confirm no overlap between participants in the intervention group and those in the comparison group. Another telephone survey was conducted six months later. At least five follow-up calls were made during different time slots during weekdays and weekends before considering the participant lost to follow-up. Upon completion of each survey, a HK\$50 (US\$6.45) supermarket coupon was mailed to participants as compensation for their time. In the intervention group, out of 531 MSM who were eligible to join the study, 131 refused to participate due to lack of time or other logistic reasons, and 400 completed the baseline survey and completed the online intervention (response rate: 75.3%). In the comparison group, out of 568 MSM who were eligible to join the study, 156 refused to participate due to lack of time or other logistic reasons, and 412 completed the baseline survey (response rate: 72.5%). The dropout rate was 12.8% (51/400) and 27.7% (114/412) at Month 6 for the intervention and comparison group respectively. Ethical approval was obtained from the institutional survey and behavioral research ethics committee (ref# SBRE-18-082).

### Online Intervention and Implementation of HIVST Services for the Intervention Group

By appointment, the CBO staff conducted a 10-minute baseline survey through telephone. All participants received the following health promotion components. The design of

the interventions was mainly based on perceived benefits and perceived barriers of HIV testing and HIVST, two constructs of the Health Belief Model [20, 21].

### Watching an Online Video Promoting HIVST

A link to access an online video was sent to participants through SMS or instant messaging applications. The video was modified from the one used in previous studies promoting HIVST among MSM in Hong Kong [18, 19]. In the first part of the video, a peer MSM narratively discussed the importance of regular HIV testing, the benefits of HIV testing in general and HIVST (e.g., accurate, convenient, able to maintain social distance and hence reduce risk of COVID-19), demonstrated its procedures, and emphasized that HIVST was easy to use. In the second part, he introduced three different modes of chargeable cost-recovery HIVST service implemented by the CBO. To ensure exposure, the video was formatted in a way that the participants could not fast-forward or skip any part of it.

### Visiting the Project Webpage

In addition to the aforementioned online video, participants could access the following health promotion components on the project webpage during the project period. They were: (a) viewing a demonstration video of how to use HIVST kits, (b) reading the description of different modes of chargeable HIVST service, (c) information about HIV epidemic among local MSM and benefits of HIV testing and HIVST, (d) contacts of the CBO staff (phone, live-chat application account, and email) to sign up for the HIVST service, (e) a discussion forum containing positive feedback of previous users. These testimonials provided cue to action supporting the use of the chargeable HIVST services, and (f) participants could post their questions in private, which would be answered by the CBO staff.

### Implementation of HIVST Services

- a. Signing up for the service: Participants could contact the CBO staff to sign up for the chargeable HIVST services. Participants were asked to select their preferable HIVST kits (oral fluid-based or blood-based), choose a service mode (see Table 1), fill in their contact information and address to receive the HIVST kit, and settle their payment (e.g., via Paypal).
- b. Receiving the HIVST kits: After payment was settled, participants received HIVST kit through repaid courier service with collection at Seven-Eleven stores, by mail in a plain envelope, or pick up at collaborative CBO.

**Table 1** Cost of different modes of HIVST services

Types of HIVST kits	HIVST services	Cost per episode
OraQuick® in-home test kit	Comprehensive version: 1) Delivery of the kit 2) Real-time instruction, pre-test, and post-test counseling support via live-chat application	HK\$500 (US\$64.1)
BioSure® HIV self-test kit	Comprehensive version: 1) Delivery of the kit 2) Real-time instruction, pre-test, and post-test counseling support via live-chat application	HK\$450 (US\$57.7)
OraQuick® in-home test kit	Simplified version: 1) Delivery of the kit 2) Real-time post-test counseling support via live-chat application	HK\$400 (US\$51.3)
BioSure® HIV self-test kit	Simplified version: 1) Delivery of the kit 2) Real-time post-test counseling support via live-chat application	HK\$350 (US\$44.9)
OraQuick® in-home test kit	Without real-time counseling support 1) Delivery of the kit	HK\$300 (US\$38.5)
BioSure® HIV self-test kit	Without real-time counseling support 1) Delivery of the kit	HK\$250 (US\$32.1)

Same practice was implemented smoothly in previous studies. A unique 6-digit ID was attached to each HIVST kit. Participants were requested to send the ID to the CBO staff to confirm receipt of the kits, and then select their preferable timeslots for implementation. Up to three weekly reminders were sent by SMS/WhatsApp/Email to those who have been sent a HIVST kit but have not confirmed receipt or selected timeslots for implementation. OraQuick® in-home test kit (OraSure Technologies, Inc.; sensitivity: 91.7%; specificity: 99.9%) and BioSure® HIV self-test kit (BioSURE, Inc.; sensitivity: 99.7%; specificity: 99.9%) were used in this study.

- c. Implementation of the comprehensive service with real-time instruction, pre-test, and post-test counseling support through live-chat application: The implementation followed the same procedures reported in previous studies [18, 19]. Through live-chat applications (e.g., Line, Skype, or WhatsApp), an experienced HIVST administrator explained how to use the HIVST kits after the users have watched a demonstration video. They then guided the participants to go through the actual self-testing procedures on-screen and in real time. Participants were guaranteed about absolute anonymity. Users could prefer not to show their faces on the screen, and they were guaranteed that no taping will be made. Standard-of-care pre-test and post-test counseling were provided to the users. It took 10 min to know about the

screening result, and the entire procedure takes about 60 min to complete, which was comparable to the time required for facility-based HIV testing and counseling.

- d. Implementation of the simplified version with real-time post-test counseling only: This service was tailored to MSM who were more familiar with the HIVST procedures, as they did not need step-by-step instruction on how to use the kits. Instruction on HIVST procedure was hence waived, while the users were sent a link about the procedures in advance. Pre-test counseling was also replaced by online pre-testing information (e.g., window period of HIVST, types of sexual behaviors that are of high risk of HIV transmission). Participants then performed the HIVST and received online real-time post-test counseling, which was the same as the comprehensive version. The simplified service would take about 20 min to complete. Such service was also developed and evaluated in the previous project [19].
- e. Implementation of HIVST without real-time counseling support: After receiving the kits, users could perform HIVST at any time without making an appointment with the CBO staff. Reporting testing results is voluntary. However, they were strongly recommended by the CBO staff to report HIVST results to the CBO official WhatsApp number to ensure support and linkage to care.
- f. Support for users with positive screening results: Those screened as HIV positive would be given immediate psychological support, and be explained about the absolute need to take up a free confirmatory HIV antibody testing offered by the Department of Health. The CBO staff would accompany them to visit the CBO or the Department of Health if desired.

## The Comparison Group

Participants in the comparison group did not have access to health promotion components received by the intervention group during the project period.

## Measures

### Outcome Measurements

One primary outcome was whether the participants had taken up at least one of the following types of HIV testing between the baseline and follow-up surveys during the 6-month follow-up period. They were: [1] HIVST, [2] HIV testing at CBOs in Hong Kong, [3] HIV testing at public hospitals/clinics in Hong Kong, [4] HIV testing at private hospitals/clinics in Hong Kong, [5] HIV testing at other organizations in Hong Kong, and [6] HIV testing in places

other than Hong Kong. Another primary outcome was the uptake of HIVST during the follow-up period.

Secondary outcomes included CAI with men, multiple sex partnerships, and sexualized drug use measured at Month 6. Sexualized drug use was defined as the use of any of the following psychoactive substances before or during sexual intercourse: ketamine, methamphetamine, cocaine, cannabis, ecstasy, Dormicum/Halcion/Erimin 5/nonprescription hypnotic drugs, heroin, cough suppressant (not for curing cough), amyl nitrite (popper), GHB/GBL, 5-methoxy-N, N-diisopropyltryptamine (Foxy), and mephedrone. Same definition was used in a number of studies [22–24].

### Baseline Background Characteristics

Information collected included socio-demographics (i.e., age, current relationship status, highest education level attained, current employment status, and monthly personal income), sexual orientation, and history of COVID-19 infection. The response categories to these background characteristics were similar to those used in previous studies targeting MSM in Hong Kong [23, 25, 26]. In addition, participants reported the use of pre-exposure prophylaxis (PrEP) and other HIV or sexually transmitted infection prevention services (receiving free condoms, peer education and pamphlets, and attending workshops).

### Process Evaluation

Participants in the intervention group completed the process evaluation of the online interventions at Month 6. They were asked: [1] whether the contents of the online video were clear, [2] whether the contents of the online video were attractive, [3] whether they were satisfied with the project webpage, and [4] whether the health promotion had increased their understanding of the importance of HIV testing and their willingness to receive HIV testing. Reasons for not using the chargeable HIVST service were collected through an open-ended question.

### Sample size Planning

According to previous data, about 60% of MSM in Hong Kong received any type of HIV testing in the past six months [18, 23]. Given the negative impact of COVID-19 on HIV testing utilization [12, 27], we estimated that 45% of local MSM would take up HIV testing within six months during the pandemic [10, 12]. A sample size of 280 participants per group would allow us to detect a minimum between-group difference of 12% in this primary outcome ( $\alpha=0.05$ , power=0.80, two-sided test; PASS 11.0, NCSS LLC).

Taking into account a 30% dropout-rate at Month 6 [23], a sample size of 400 per group (800 in total) was required.

### Statistical Analysis

Between-group differences in baseline characteristics were compared by using chi-square tests. Baseline characteristics of participants who completed the survey at Month 6 and those who were lost to follow-up were also compared using chi-square tests. Intention-to-treat analysis was used for the outcome analyses. Missing data were all binary variables. Since there was no missing data among participants who completed the Month 6 follow-up survey, the missing rate was equal to the dropout rate (12.7% in the intervention group and 27.7% in the comparison group). We filled the missing outcome values at Month 6 using multiple imputations. Markov Chain Monte Carlo method was used to impute data with the arbitrary pattern of missing values, while the Monotone methods were used to impute data having a monotone pattern of missing values. Predictors included baseline background characteristics and baseline values of these outcomes. Logistic regression models were used to test the between-group difference in the imputed primary and secondary outcomes, after controlling for baseline background characteristics with  $p<.05$  in between-group comparisons. Crude odds ratios (OR), adjusted odds ratios (AOR), and their 95% confidence interval were obtained. Within-group changes in the imputed primary and secondary outcomes (Month 6 versus baseline) were investigated using McNemar tests. SPSS 26.0 (Chicago, IL, USA) was used for data analysis, and  $p<.05$  was considered statistically significant.

## Results

### Descriptive Statistics

At baseline, over half of the participants were aged no more than 30 years (59.6%,  $n=484$ ), currently single (81.8%,  $n=664$ ), had obtained tertiary education (85.3%,  $n=693$ ), with full-time employment (69.8%,  $n=567$ ), and identified themselves as gay (83.3%,  $n=676$ ). About one-sixth (16.7%,  $n=136$ ) reported a monthly income of HK\$40,000 (US\$5,161) or above. In the past six months, 43.6% ( $n=354$ ) reported CAI with men, 49.9% ( $n=405$ ) had multiple male sex partnerships, and 6.2% ( $n=50$ ) reported sexualized drug use. Regarding HIV testing utilization in the past six months, 43.0% ( $n=349$ ) received any type of HIV testing and 13.8% ( $n=112$ ) used HIVST, respectively. In addition, 5.7% ( $n=46$ ) of the participants reported the use of PrEP, and 37.1% ( $n=301$ ) used other HIV or sexually transmitted

infection prevention services in the past six months. None of them reported history of COVID-19 infection. Apart from current employment status ( $p < .001$ ), CAI with men ( $p = .04$ ), and sexualized drug use ( $p = .03$ ), no significant between-group difference was found ( $p$  values between 0.06 and 0.99) (Table 2). Therefore, current employment status, CAI with men, and sexualized drug use were controlled in the subsequent comparisons of primary and secondary outcomes.

The dropout rate in the intervention group and the comparison group at Month 6 was 12.8% and 27.7%, respectively. No significant differences in the baseline characteristics were found between participants who completed the follow-up evaluation and those who were lost to follow-up at Month 6 (Table S1 of Appendix 1).

**Table 2** Baseline characteristics of participants

	All participants (n = 812)	Intervention group (n = 400)	Comparison group (n = 412)	P values
	n (%)	n (%)	n (%)	
<b>Sociodemographic</b>				
Age group, years				
18–30	484 (59.6)	224 (56.0)	260 (61.3)	
31–40	232 (28.6)	129 (32.3)	103 (25.0)	
>40	96 (23.7)	47 (11.8)	49 (11.9)	0.07
Current relationship status				
Currently single	664 (81.8)	329 (82.3)	335 (81.3)	
Married or cohabited with a man	143 (17.6)	68 (17.0)	75 (18.2)	
Married or cohabited with a woman	5 (0.6)	3 (0.8)	2 (0.5)	0.81
Highest education level attained				
Secondary or below	119 (14.7)	49 (12.3)	70 (17.0)	
Tertiary or above	693 (85.3)	351 (87.7)	342 (83.0)	0.06
Current employment status				
Full-time	567 (69.8)	304 (76.0)	263 (63.8)	
Part-time/self-employed/unemployed/retired/students/others	245 (30.2)	96 (24.0)	149 (36.2)	<0.001
Monthly personal income, HK\$ (US\$)				
<40,000 (5,161)	676 (83.3)	323 (80.8)	353 (85.7)	
≥40,000 (5,161)	136 (16.7)	77 (19.2)	59 (14.3)	0.06
Sexual orientation				
Gay	676 (83.3)	339 (84.8)	337 (81.8)	
Bisexual	108 (13.3)	53 (13.3)	55 (13.3)	
Uncertain	28 (3.5)	8 (2.0)	20 (4.9)	0.08
History of COVID-19 infection				
No	0 (0.0)	0 (0.0)	0 (0.0)	
Yes	812 (100.0)	400 (100.0)	412 (100.0)	0.99
<b>Sexual risk behaviors in the past six months, Yes</b>				
Condomless anal intercourse with a man	354 (43.6)	189 (47.3)	165 (40.0)	0.04
Multiple male sex partnerships	405 (49.9)	207 (51.7)	198 (48.1)	0.29
Sexualized drug use	50 (6.2)	32 (8.0)	18 (4.4)	0.03
<b>Utilization of different types of HIV testing in the past six months, Yes</b>				
HIV testing at community-based organizations (CBO) in Hong Kong	213 (26.2)	104 (26.0)	109 (26.5)	0.83
HIV testing at public hospitals/clinics in Hong Kong	55 (6.8)	29 (7.2)	26 (6.3)	0.59
HIV testing at private hospitals/clinics in Hong Kong	21 (2.6)	12 (3.0)	9 (2.2)	0.46
HIV testing at other organizations in Hong Kong	16 (2.0)	9 (2.3)	7 (1.7)	0.57
HIV testing in places other than Hong Kong	1 (0.1)	1 (0.3)	0 (0.0)	0.31
Home-based HIV self-testing (HIVST)	112 (13.8)	54 (13.5)	58 (14.1)	0.81
Any of above	349 (43.0)	179 (44.8)	170 (41.3)	0.32
<b>Utilization of other HIV prevention services in the past six months, Yes</b>				
Use of pre-exposure prophylaxis	46 (5.7)	27 (6.8)	19 (4.6)	0.19
Use of other HIV or sexually transmitted infection prevention services (receiving free condoms, peer education and pamphlets, and attending workshops)	301 (37.1)	158 (39.5)	143 (34.7)	0.16

## Primary Outcomes

At Month 6, participants in the intervention group reported significantly higher uptake of any type of HIV testing (57.0% versus 49.0%, AOR: 1.43, 95%CI: 1.04, 1.97,  $p=.03$ ) and HIVST (25.8% versus 14.8%, AOR: 2.04, 95%CI: 1.34, 3.09,  $p=.001$ ) during the follow-up period, as compared to those in the comparison group (Table 3). Utilization of different types of HIV testing during the follow-up period among participants who completed the Month 6 follow-up survey was presented in Table S2 of Appendix 2. Apart from HIVST (25.8% [90/349] in the intervention group versus 15.4% [46/298] in the comparison group,  $p=.001$ ), there was no difference in the uptake rate of other types of HIV testing ( $p$  values between 0.31 and 0.78). Seven participants in the intervention group used chargeable HIVST services during the follow-up period; four of them used OraQuick® in-home test kit without real-time counseling support and

three of them used BioSure® HIV self-test kit without real-time counseling support. All seven users reported their HIVST results to CBO staff. No participants in the comparison group used chargeable HIVST services implemented by the CBO during the study period. Among participants who had received HIV testing during the follow-up period, no participants (0/201) in the intervention group and three participants (3/153) in the comparison group reported positive results, respectively.

Significant increases in the uptake of any type of HIV testing were observed in both the intervention group (57.0% at Month 6 versus 44.8% at baseline,  $p<.001$ ) and the comparison group (49.0% at Month 6 versus 41.3% at baseline,  $p=.01$ ). However, within-group increase in HIVST uptake was only observed in the intervention group (25.8% at Month 6 versus 13.5% at baseline,  $p<.001$ ), but not in the comparison group (14.8% at Month 6 versus 14.1% at baseline,  $p=.90$ ). (Table 3)

**Table 3** Between-group and within group comparison of primary and secondary outcomes

	Interven- tion group (n = 400)	Compara- son group (n = 412)	OR (95%CI), p value	AOR (95%CI), p value
	n (%)	n (%)		
<b>Primary outcomes: HIV testing uptake</b>				
Any type of HIV testing				
Baseline	179 (44.8)	170 (41.3)	1.15 (0.87, 1.52), $p=.32$	1.05 (0.78, 1.40) $p=.75$
Month 6 <sup>1</sup>	228 (57.0)	202 (49.0)	1.38 (1.02, 1.88) $p=.04$	1.43 (1.04, 1.97) $p=.03$
Month 6 <sup>1</sup> vs. Baseline, p value	$p<.001$	$p=.01$	N.A.	N.A.
HIVST				
Baseline	54 (13.5)	58 (14.1)	0.96 (0.64, 1.42), $p=.81$	0.92 (0.61, 1.38) $p=.68$
Month 6 <sup>1</sup>	103 (25.8)	61 (14.8)	2.02 (1.34, 3.04) $p=.001$	2.04 (1.34, 3.09) $p=.001$
Month 6 <sup>1</sup> vs. Baseline, p value	$p<.001$	$p=.90$	N.A.	N.A.
<b>Secondary outcomes: Sexual risk behaviors</b>				
Condomless anal intercourse with a man				
Baseline	189 (47.3)	165 (40.0)	1.34 (1.02, 1.77), $p=.04$	1.33 (1.00, 1.77) $p=.05$
Month 6 <sup>1</sup>	195 (48.8)	178 (43.2)	1.26 (0.94, 1.69) $p=.13$	1.08 (0.76, 1.55) $p=.66$
Month 6 <sup>1</sup> vs. Baseline, p value	$p=.77$	$p=.20$	N.A.	N.A.
Multiple male sex partnerships				
Baseline	207 (51.7)	198 (48.1)	1.16 (0.88, 1.53), $p=.29$	1.08 (0.81, 1.44) $p=.59$
Month 6 <sup>1</sup>	206 (51.5)	182 (44.2)	1.34 (0.99, 1.81) $p=.06$	1.21 (0.88, 1.65) $p=.24$
Month 6 <sup>1</sup> vs. Baseline, p value	$p=.61$	$p=.11$	N.A.	N.A.
Sexualized drug use				
Baseline	32 (8.0)	18 (4.4)	1.90 (1.05, 3.45) $p=.03$	1.72 (0.95, 3.17) $p=.08$
Month 6 <sup>1</sup>	25 (6.3)	16 (3.9)	1.68 (0.85, 3.33) $p=.14$	1.34 (0.65, 2.79) $p=.34$
Month 6 <sup>1</sup> vs. Baseline, p value	$p=.38$	$p=.82$	N.A.	N.A.

<sup>1</sup> 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

AOR: adjusted odds ratios, odds ratios adjusted for baseline characteristics with significant between-group difference (current employment status, condomless anal intercourse with a man, and sexualized drug use)

N.A.: not applicable



**Table S2** Descriptive statistics of utilization of different types of HIV testing at Month 6 (among participants who completed the Month 6 follow-up survey)

	Interven- tion group (n=349)	Compari- son group (n=298)	P val- ues
	n (%)	n (%)	
HIV testing at community-based organizations (CBO) in Hong Kong	97 (27.8)	91 (30.5)	0.44
HIV testing at public hospitals/clinics in Hong Kong	23 (6.6)	24 (8.1)	0.48
HIV testing at private hospitals/clinics in Hong Kong	13 (3.7)	7 (2.3)	0.31
HIV testing at other organizations in Hong Kong	6 (1.7)	6 (2.0)	0.78
HIV testing in places other than Hong Kong	0 (0.0)	1 (0.3)	0.28
Home-based HIV self-testing (HIVST)	90 (25.8)	46 (15.4)	0.001
Any of above	201 (57.6)	153 (51.3)	0.11

## Secondary Outcomes

At Month 6, there was no between-group difference in the prevalence of CAI with men, multiple male sex partnerships, or sexualized drug use. No within-group changes were observed in these secondary outcomes when comparing the Month 6 versus the baseline data (Table 3).

## Process Evaluation

Among 349 participants in the intervention group who completed the process evaluation, 85.1% (n=297) believed the contents of the online video were clear, 53.3% (n=186) found the contents attractive, and 60.2% (n=210) were satisfied with the project webpage. In addition, 77.1% (n=269) perceived that the online interventions were helpful in increasing their awareness about the importance of HIV testing, and 54.7% (n=191) perceived that the online interventions increased their willingness to receive HIV testing. The main reasons for not using the chargeable HIVST services included the belief that the HIVST service was too expensive (25.8%, n=90), perceiving low risk of HIV infection and hence no need to use HIV testing (14.0%, n=49), and being able to obtain free HIVST kits through other channels (3.4%, n=12).

Among 303 participants in the comparison group who completed the Month 6 follow-up evaluation, 58.7% (n=178) utilized HIV prevention services other than HIV testing in the past six months. These services included testing for other sexually transmitted infections (37.6%, n=114), receiving free condoms, peer education and pamphlets, and attending workshops (29.7%, n=90), and using pre-exposure prophylaxis (7.9%, n=24).

## Discussion

To our knowledge, this is one of the first studies to evaluate the effectiveness of interventions to promote HIV testing service utilization among Chinese MSM during the COVID-19 pandemic. As compared to the comparison group, the intervention group had significantly higher uptake of any type of HIV testing (57.0% versus 49.0%) and HIVST (25.8% versus 14.8%) during the six-month follow-up period. The interventions were well received based on positive process evaluation results. Having a parallel comparison group increased the internal validity of our findings, which was a strength of this study.

During the follow-up period, the COVID-19 situation was stable and under control. The government relieved some strict COVID-19 control measures implemented during the third and fourth waves of the outbreak. Some barriers to accessing HIV testing (e.g., closure of testing sites, fear of COVID-19) were hence reduced. This could explain the within-group increase in HIV testing utilization in both groups of participants. However, the HIV testing rate observed in the comparison group at Month 6 was still below the level reported in the time before the COVID-19 pandemic (49.0% versus about 60%) [23]. Such findings were similar to the situation observed among MSM in mainland China. The HIV testing utilization might take a relatively long time to rebound after the pandemic received initial control [12]. As compared to the comparison group, the implementation of the HIVST promotion brought a significant increase of about 10% in the use of any HIV testing service over a six-month follow-up period. About 60% of the participants in the intervention group received any type of HIV testing at Month 6. Such uptake rate was similar to the time before the COVID-19 pandemic. The findings suggested that the online health promotion program implemented by the CBO could increase HIV testing service utilization during the COVID-19 pandemic among MSM in Hong Kong.

The use of HIVST was significantly higher in the intervention group compared to the comparison group. However, there were no between-group differences in the uptake of other types of HIV testing at Month 6. The uptake of HIVST in the intervention group was slightly lower than that of the participants of a HIVST promotion program implemented in the United States (25.8% versus 34%). The uptake of HIVST was also much lower than that reported by MSM in mainland China during the pandemic (44–46%) [12]. One possible reason was that MSM in Hong Kong mainly relied on free facility-based HIV testing and counseling services provided by CBOs and governmental clinics [28]. These services were most affected during the COVID-19 outbreak.

Service providers should consider allocating more resources to HIVST services during the pandemic.

Regarding the secondary outcomes, there were no between-group differences or within-group changes in CAI, multiple male sex partnerships, or sexualized drug use among our participants. The findings suggested that most MSM in Hong Kong continued to engage in sexual risk behaviors after the COVID-19 outbreak. Given the important role of HIV testing in HIV prevention, the decrease in HIV testing during the pandemic might lead to an outbreak of HIV and/or other sexually transmitted infections among MSM in Hong Kong. Such findings highlighted the importance of promoting HIV testing uptake among MSM during the pandemic.

Although the online intervention significantly increased HIV testing and HIVST uptake, only seven MSM used the cost-recovery HIVST services during the study period. The low utilization rate urged the CBO to reconsider the public health impact of implementing such service model. From the angle of social marketing, the chargeable HIVST services faced serious competition. As mentioned by the participants in the process evaluation, there were other options of free HIV testing or HIVST for MSM during the pandemic. For example, they could still purchase cheaper HIVST kits from online market places, or obtain free HIVST kits from other sources (e.g., friends). The chargeable HIVST service was less attractive to them. Moreover, the COVID-19 had a strong negative impact on the economy. Many Hong Kong residents experienced a decrease in income caused by reduced working hours, job loss or furlough [29]. Therefore, the cost, as a barrier of HIVST, was amplified during the pandemic [30]. Service providers should promote free HIV testing or HIVST during the pandemic.

This study had a number of limitations. First, we did not use a randomized controlled trial, the most rigorous evaluation design, to evaluate the effectiveness of the interventions. The quasi-experimental evaluation design used in this study could not control all issues threatening the internal validity. Second, we did not measure attitudes toward HIV testing. Changes in attitudes might lead to actual behavioral changes. Third, the use of HIV testing other than the chargeable HIVST services was self-reported by the participants. Such responses might have been over-reported due to social desirability. Fourth, like most of the interventional studies, participants were recruited by convenient sampling. We did not collect information on MSM who refused to participate in the study. Selection bias existed. As compared to a representative sample of Hong Kong MSM ( $n=4133$ ), our participants had a similar prevalence of CAI but were slightly younger [31]. The education and income levels of our participants were comparable to those reported by previous studies of MSM in Hong Kong [23, 25, 26]. Fifth, attrition

bias existed due to dropout. However, since the difference in baseline characteristics was not different between participants who completed Month 6 follow-up evaluation and those who were lost to follow-up, we expected the attrition bias would be limited. Sixth, MSM without internet access could not benefit from this program. Since over 96% of Hong Kong people have a smartphone, access to the online interventions should not be a big barrier for MSM in Hong Kong. Since the program did not provide free HIVST kits, its effectiveness might be lower among the less privileged populations with fewer resources. Moreover, the COVID-19 control measures implemented in Hong Kong were different from those in mainland China (e.g., without strict measures such as compulsory universal COVID-19 screening or lockdown), the duration of disruption on HIV testing services was longer in Hong Kong in 2020 and 2021. In contrast, COVID-19 was under control in other Chinese cities after May 2020. Caution should be taken when generalizing the findings to other Chinese cities. Furthermore, the findings are most applicable to the time when the zero-COVID policy was implemented. Starting from August 2022, Hong Kong relieved its COVID-19 control measures and tried to resume normal. Barriers to accessing HIV testing (e.g., social distancing) were largely reduced.

## Conclusions

In sum, the online interventions promoting HIVST implemented by the CBO significantly increased the uptake of any type of HIV testing and HIVST during the COVID-19 pandemic. However, one of the intervention components, the chargeable cost-recovery HIVST service, was less attractive to MSM. Service providers should consider implementing free HIVST services to further improve the effectiveness of their health promotion program.

## Appendix 1

**Table S1** Comparing baseline characteristics between participants being followed up and those who were lost-to-follow-up at Month 6

Intervention group			Comparison group		
Being followed up ( $n=349$ ) n (%)	Loss-to-follow-up ( $n=51$ ) n (%)	P values	Being followed up ( $n=298$ ) n (%)	Loss-to-follow-up ( $n=114$ ) n (%)	P values

### Sociodemographic

Age group, years

**Table S1** Comparing baseline characteristics between participants being followed up and those who were lost-to-follow-up at Month 6

	Intervention group		Comparison group			
18–30	190 (54.5)	34 (66.7)		178 (59.7)	82 (71.9)	
31–40	115 (33.0)	14 (27.5)		82 (27.5)	21 (18.4)	
>40	44 (12.6)	3 (5.9)	0.19	38 (12.8)	11 (9.6)	0.07
Current relationship status						
Currently single	291 (83.4)	38 (74.5)		246 (82.6)	89 (78.1)	
Married or cohabited with a man	56 (16.0)	12 (23.5)		51 (17.1)	24 (21.1)	
Married or cohabited with a woman	2 (0.6)	1 (2.0)	0.22	1 (0.3)	1 (0.9)	0.50
Highest education level attained						
Secondary or below	44 (12.6)	5 (9.8)		45 (15.1)	25 (21.9)	
Tertiary or above	305 (87.4)	46 (90.2)	0.57	253 (84.9)	89 (78.1)	0.10
Current employment status						
Full-time	269 (77.1)	35 (68.6)		196 (65.8)	67 (58.8)	
Part-time/self-employed/unemployed/retired/students/others	80 (22.9)	16 (31.4)	0.19	102 (34.2)	47 (41.2)	0.19
Monthly personal income, HK\$ (US\$)						
<40,000 (5,161)	281 (80.5)	42 (82.4)		255 (85.6)	97 (85.8)	
≥40,000 (5,161)	68 (19.5)	9 (17.6)	0.76	43 (14.4)	16 (14.2)	0.94
Sexual orientation						
Gay	300 (86.0)	39 (76.5)		245 (82.2)	92 (80.7)	
Bisexual	44 (12.6)	9 (17.6)		41 (13.8)	14 (12.3)	
Uncertain	5 (1.4)	3 (5.9)	0.06	12 (4.0)	8 (7.0)	0.43

**Table S1** Comparing baseline characteristics between participants being followed up and those who were lost-to-follow-up at Month 6

	Intervention group		Comparison group			
<b>Sexual risk behaviors in the past six months, Yes</b>						
Condomless anal intercourse with a man	169 (48.4)	20 (39.2)	0.22	127 (42.6)	38 (33.3)	0.09
Multiple male sex partnerships	181 (51.9)	26 (51.0)	0.91	149 (50.0)	49 (43.0)	0.20
Sexualized drug use	28 (8.0)	4 (7.8)	0.97	11 (3.7)	7 (6.1)	0.28
<b>Utilization of different types of HIV testing in the past six months, Yes</b>						
HIV testing at community-based organizations (CBO) in Hong Kong	94 (26.9)	10 (19.6)	0.27	85 (28.5)	24 (21.1)	0.12
HIV testing at public hospitals/clinics in Hong Kong	22 (6.3)	7 (13.7)	0.06	19 (6.4)	7 (6.1)	0.93
HIV testing at private hospitals/clinics in Hong Kong	11 (3.2)	1 (2.0)	0.64	6 (2.0)	3 (2.6)	0.70
HIV testing at other organizations in Hong Kong	8 (2.3)	1 (2.0)	0.88	7 (2.3)	0 (0.0)	0.10

**Table S1** Comparing baseline characteristics between participants being followed up and those who were lost-to-follow-up at Month 6

	Intervention group			Comparison group		
HIV testing in places other than Hong Kong	1 (0.3)	0 (0.0)	0.70	0 (0.0)	0 (0.0)	N.A.
Home-based HIV self-testing (HIVST)	50 (14.3)	4 (7.8)	0.21	46 (15.4)	12 (10.5)	0.20
Any of above	160 (45.8)	19 (37.3)	0.25	132 (44.3)	38 (33.3)	0.06
<b>Utilization of other HIV prevention services in the past six months, Yes</b>						
Use of pre-exposure prophylaxis	23 (6.6)	4 (7.8)	0.39	15 (5.0)	4 (3.5)	0.68
Use of other HIV or sexually transmitted infection prevention services (receiving free condoms, peer education and pamphlets, and attending workshops)	137 (39.3)	21 (41.2)	0.79	102 (34.2)	41 (36.0)	0.74

N.A.: not applicable

## Appendix 2

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## Declarations

**Conflict of interest** The authors declare that they have no conflict of interest.

**Research Involving Human Participants** All procedures in studies involving human participants were in accordance to the institutional survey and behavioral research ethics committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical approval was obtained from the institutional survey and behavioral research ethics committee (ref# SBRE-18-082).

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

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