Willingness to receive COVID-19 vaccination among people living with HIV and AIDS in China: A nationwide cross-sectional online survey

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Abstract

Background: People living with HIV and AIDS (PLWHA) could benefit from COVID-19 vaccination. There is a dearth of evidence on willingness to receive COVID-19 vaccination among PLWHA.

Objective: This study investigated willingness to receive COVID-19 vaccination among a national sample of PLWHA.

Methods: This cross-sectional online survey investigated factors associated with willingness to receive COVID-19 vaccination among PLWHA aged 18-65 years living in eight conveniently selected Chinese metropolitan cities between January and February 2021. Eight community-based organizations (CBO) providing services to PLWHA facilitated the recruitment. Eligible PLWHA completed an online survey developed using a widely used encrypted web-based survey platform in China. Logistic regression models and path analysis were used in data analysis.

Results: Out of 10,845 PLWHA approached by the CBO, 2740 completed the survey. This analysis was performed among 2570 participants who had never received COVID-19 vaccination. Over half of the participants reported willingness to receive COVID-19 vaccination (57.2%, 1470/2570). After adjusting for potential confounders, all four constructs of the Theory of Planned Behavior (TPB) were significantly associated with willingness to receive COVID-19 vaccination, including positive attitudes (adjusted odds ratio, aOR: 1.11, 95%CI: 1.09, 1.12, P<.001), negative attitudes (aOR: 0.96, 95%CI: 0.94, 0.97), perceived support from significant others (perceived subjective norm) (aOR: 1.53, 95%CI: 1.46, 1.61), and perceived higher behavioral control (aOR: 1.13, 95%CI: 1.11, 1.14). At the interpersonal level, receiving advice supportive of COVID-19 vaccination from doctors (aOR: 1.99, 95%CI: 1.65, 2.40), CBO staff (aOR: 1.89, 95%CI: 1.51, 2.36), friends and/or family

members (aOR: 3.22, 95%CI: 1.93, 5.35), and PLWHA peers (aOR: 2.38, 95%CI: 1.85, 3.08) were associated with higher willingness to receive COVID-19 vaccination. Overall opinion supporting COVID-19 vaccination for PLWHA on Internet or social media was also positively associated with willingness to receive COVID-19 vaccination (aOR: 1.59, 95%CI: 1.31, 1.94). Path analysis indicated that interpersonal-level variables was indirectly associated with willingness to receive COVID-19 vaccination through TPB-related perceptions (?=0.43, 95% CI=0.37, 0.51, P<.001).

Conclusions: PLWHA in China reported a relatively low willingness to receive COVID-19 vaccination. Internet/social media and interpersonal communications may be a major source of influence on PLWHA's perceptions and willingness to receive COVID-19 vaccination.

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Willingness to receive COVID-19 vaccination among people living with HIV and AIDS in China: A nationwide cross-sectional online survey

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Abstract

Background: HIV infection is a significant independent risk for both severe COVID-19 presentation at hospital admission and in-hospital mortality. Available information suggested that people living with HIV and AIDS (PLWHA) could benefit from COVID-19 vaccination. However, there is a dearth of evidence on willingness to receive COVID-19 vaccination among PLWHA.

Objective: This study investigated willingness to receive COVID-19 vaccination among a national sample of PLWHA.

Methods: This cross-sectional online survey investigated factors associated with willingness to receive COVID-19 vaccination among PLWHA aged 18-65 years living in eight conveniently selected Chinese metropolitan cities between January and February 2021. Eight community-based organizations (CBO) providing services to PLWHA facilitated the recruitment. Eligible PLWHA completed an online survey developed using a widely used encrypted web-based survey platform in China. We fitted a single logistic regression model to obtain adjusted odds ratios (aOR), which involved one of the independent variables of interest and all significant background variables. Path analysis were also used in data analysis.

Results: Out of 10,845 PLWHA approached by the CBO, 2740 completed the survey, and 170 had received at least one dose of COVID-19 vaccination. This analysis was performed among 2570 participants who had never received COVID-19 vaccination. Over half of the participants reported willingness to receive COVID-19 vaccination (57.2%, 1470/2570). Perceptions related to COVID-19 vaccination were significantly associated with willingness to receive COVID-19 vaccination, including positive attitudes (aOR: 1.11, 95%CI: 1.09, 1.12, *P*<.001), negative attitudes (aOR: 0.96, 95%CI: 0.94, 0.97), perceived support from significant others (perceived subjective norm) (aOR: 1.53, 95%CI: 1.46, 1.61), and perceived higher behavioral control (aOR: 1.13, 95%CI: 1.11, 1.14). At the interpersonal level, receiving advice supportive of COVID-19 vaccination from doctors (aOR: 1.99, 95%CI: 1.65, 2.40), CBO staff (aOR: 1.89, 95%CI: 1.51, 2.36), friends and/or family members

(aOR: 3.22, 95%CI: 1.93, 5.35), and PLWHA peers (aOR: 2.38, 95%CI: 1.85, 3.08) were associated with higher willingness to receive COVID-19 vaccination. Overall opinion supporting COVID-19 vaccination for PLWHA on Internet or social media was also positively associated with willingness to receive COVID-19 vaccination (aOR: 1.59, 95%CI: 1.31, 1.94). Path analysis indicated that interpersonal-level variables was indirectly associated with willingness to receive COVID-19 vaccination through perceptions (β=0.43, 95% CI=0.37, 0.51, *P*<.001).

Conclusions: As compared to PLWHA in other countries and general population in most part of the world, PLWHA in China reported a relatively low willingness to receive COVID-19 vaccination. Internet/social media and interpersonal communications may be a major source of influence on PLWHA's perceptions and willingness to receive COVID-19 vaccination.

Keywords: People living with HIV and AIDS; COVID-19 vaccination; willingness; perceptions; internet/social media influences; interpersonal communication

Introduction

The World Health Organization (WHO) confirmed that HIV infection is a significant independent risk factor for both severe COVID-19 presentation at hospital admission and in-hospital mortality [1]. It is essential to take additional measures to prevent people living with HIV and AIDS (PLWHA) from COVID-19.

COVID-19 vaccine offers best hope for ending the pandemic. Simulation experiments showed that when the vaccine efficacy was 80%, a 75% coverage could end the COVID-19 pandemic without any other control measures [2]. Relatively small number of PLWHA were involved in the phase III COVID-19 vaccine trials. The Pfizer study and the Oxford/AstraZeneca study recruited 196 and 157 PLWHA, respectively. However, the data on vaccine efficacy for PLWHA was not included in the publications that had led to their approval in the United States and the United Kingdom [3, 4]. The Moderna study included 176 PLWHA [5]. One PLWHA who received the placebo and none received the vaccine developed COVID-19. The Janssen (Johnson & Johnson) study involved 1218 PLWHA [6]. Two PLWHA who received the vaccine and four who received the placebo developed COVID-19. There were 201 PLWHA in the Novarax study. The overall vaccine efficacy was 49.4%, with a higher efficacy when excluding PLWHA from the analysis (60%) [7]. Studies observed similar immune responses and adverse events to mRNA and adenovirus vector COVID-19 vaccines between PLWHA and HIV-negative individuals [8-12]. Despite limited evidence, available information suggested that COVID-19 vaccines recommended by the WHO are safe for PLWHA. There is no evidence to support a less robust response to COVID-19 vaccines among PLWHA. PLWHA could benefit from COVID-19 vaccination.

The recommendations or guidelines on COVID-19 vaccination for PLWHA are inconsistent across countries. The WHO, the United States Department of Health and Human Services, the British HIV Association, and health authorities in Australia recommend PLWHA to receive COVID-19 vaccination regardless of their CD4+ T cell counts [1, 13-15]. PLWHA is one of the priority groups

to receive COVID-19 vaccination in the United Kingdom, the United States, and Australia [13-15]. Moreover, the Centers for Disease Control and Prevention (CDC) recommend PLWHA who are moderately to severely immunocompromised should receive an additional dose of mRNA COVID-19 vaccine after the initial doses [16]. In Asia-Pacific region, Singapore used to recommend COVID-19 vaccination to PLWHA who are on antiretroviral therapy (ART) and with suppressed HIV viral load and CD4+ T cell counts over 200 cells/μL [17]. Their recommendation expanded to all PLWHA regardless of ART, viral suppression or CD4+ T cell counts since July 2021 [17]. At the time when this study was conducted, immunodeficiency (including HIV infection) was listed as a precaution for COVID-19 vaccination in China; PLWHA should seek advices from doctors regarding COVID-19 vaccination [18]. The guideline was updated one month after the completion of this study (March 2021) and started recommending COVID-19 vaccination for PLWHA regardless of their CD4+ T cell counts [18].

Vaccine hesitancy hindered the successful control of the COVID-19 pandemic. Therefore, it is helpful for governments to plan interventions to improve people's awareness of the safety and benefits of the COVID-19 vaccine and reduce the vaccine hesitancy. In order to promote the COVID-19 vaccination of PLWHA, it is necessary to understand their willingness to receive COVID-19 vaccination and related facilitators/barriers. However, most studies investigating willingness to receive COVID-19 vaccination and its associated factors were conducted among the general population and medical professionals [19-21], the findings might not be applicable to PLWHA. To our knowledge, only two published studies investigated COVID-19 vaccine hesitancy among PLWHA in the United States and France [22, 23]. The results showed that 28.7% of PLWHA in France declared hesitancy to be vaccinated against COVID-19 [22]. Over 30% of PLWHA in the United States indicated that if a vaccine was available to prevent COVID-19, they would not trust it (34%) or want to get it (32%) [23]. Concerns about their health, and the belief that COVID-19 vaccination should be mandatory and important for people with chronic disease were associated with

higher willingness to receive COVID-19 vaccination, while previous history of vaccination refusal, mistrust in public health information, and concerns related to side effects were shown to be barriers [22, 23].

We applied the socio-ecological model to understand factors associated with willingness to receive COVID-19 vaccination among PLWHA at individual-, interpersonal- and socio-structural-level [24]. Interventions addressing influencing factors at multiple levels are more likely to be successful [24]. The socio-ecological model was used successfully to explain compliance to COVID-19 personal preventive measures among Chinese populations [25]. At the socio-structural-level, two COVID-19 vaccination delivery models were implemented simultaneously in China at the time of this study. Individuals can make an appointment to receive COVID-19 vaccination in some cities, while COVID-19 vaccination is mainly arranged by the employers and does not allow individuals to make appointment in other Chinese cities. People have the right to refuse such arrangement. Currently, since the amount of vaccines is inadequate to cover the entire Chinese population at the initial phase, priority is given to subgroups with elevated risks of developing COVID-19 (e.g., healthcare workers, pandemic-control staff, cold-chain workers, etc.). Some Chinese cities also reported a shortage of COVID-19 vaccines. We expected these socio-structural-level factors would influence PLWHA's willingness to receive COVID-19 vaccination. At the individual-level, perceived efficacy, concerns about side effects, others' acceptance, and confidence to receive the vaccines influenced people's willingness to receive COVID-19 vaccination [26-30]. At the interpersonal-level, people were exposed to information related to COVID-19 vaccination through interpersonal communication or Internet/social media. Higher exposure to positive information related to COVID-19 vaccination on social media was associated with a higher willingness to receive such vaccination among Chinese factory workers [27]. Interpersonal communication, such as receiving advices from doctors and family members were also positively associated with willingness to receive COVID-19 vaccination among the general population in China [28]. Clinical doctors and community-based

organizations (CBO) staff are the main service providers for PLWHA [31]. Their advices regarding COVID-19 vaccination may have a great impact on PLWHA's decision to accept such vaccination. A recent study suggested that exposure to positive information related to COVID-19 vaccination increased perceptions favouring such vaccination [27]. In this study, we hypothesized that exposure to information supporting PLWHA to receive COVID-19 vaccination through Internet/social media and interpersonal communication would influence PLWHA's perception of such vaccination, and hence affect their willingness to receive COVID-19 vaccination.

To our knowledge, there was no study investigating willingness to receive COVID-19 vaccination among PLWHA in China. To address the knowledge gaps, this study investigated willingness to receive COVID-19 vaccination among a national sample of PLWHA. We examined the effects of factors including socio-demographics, HIV-related characteristics, individual-level factors (perceptions related to COVID-19 vaccination), interpersonal-level variables (exposure to COVID-19 vaccination related information through Internet/social media and interpersonal communication), and social-structural-level factors (COVID-19 vaccination delivery model, members of priority groups, and shortage in vaccine supply). We further tested the hypothesis that perceptions of COVID-19 vaccination would mediate the association between interpersonal-level variables and willingness to receive COVID-19 vaccination.

Methods

Study design

The study is a multicenter cross-sectional online survey conducted in eight conveniently selected large Chinese cities between January and February 2021. These cities included two in the North (Tianjin and Beijing), two in the Northeast (Shenyang, Hohhot), one in the East (Nanjing), and three in the South (Nanning, Guangzhou and Shenzhen). Beijing is the capital city of China. Shenzhen is a major special economic zone in China bordering Hong Kong in the south. The other six cities are capital cities of the provinces. Reasons for selecting these cities included: 1) each city has a CBO

providing services to PLWHA; 2) each city has a large number of PLWHA; and 3) COVID-19 vaccination was first scaled up in these sites. At the time of this study, people in Beijing, Guangzhou, and Shenzhen could make an appointment to receive COVID-19 vaccination. The procedures of making an appointment are simple. People first download a smartphone application developed by the health bureau. After log in, they can choose time and location to receive COVID-19 vaccination. In the other five cities, vaccination was arranged by employers and did not allow individuals to make appointment. Only two types of inactivated COVID-19 vaccines (Sinovac-CoronaVac and Sinopharm) were available in China during the study period. They were provided by designated community vaccination centers and people could only receive them on sites in these centers. Immunodeficiency (including HIV infection) was listed as a precaution for COVID-19 vaccination in China during the study period; PLWHA should seek advices from doctors regarding COVID-19 vaccination [18]. Participants who had never received COVID-19 vaccination were asked about their willingness to receive COVID-19 vaccination. The context of this study was shown in Figure 1.

Study population

Study participants were individuals aged 18-65 years who have been diagnosed with HIV or AIDS and were living in one of the eight cities. We did not include PLWHA older than 65 years old, as COVID-19 vaccination was not approved for this age group in China at the time of the survey. Exclusion criteria included: 1) being illiterate and unable to complete the questionnaire survey; and 2) being ineligible for COVID-19 vaccination (e.g., pregnancy, latency, severe allergy to previous vaccination).

Recruitment and data collection

The Eight CBO which were mainly providing services to the marginalized populations (e.g., PLWHA and HIV high-risk populations), one in each study site, facilitated the recruitment through their networks. These CBO have been working closely with HIV clinical service providers. CBO in China are the main providers of HIV outreach services to PLWHA, as these routine tasks have been

transferred from government agencies to CBO [31]. A high proportion of PLWHA are followed up by the CBO. The WeChat is the most common live-chat application used by CBO to connect with PLWHA clients. The research team provided training for CBO staff who were responsible for communications with PLWHA within the scope of their routine service. Participants were recruited by posting advertisements in the WeChat groups involving PLWHA clients kept by the CBO. The advertisement contained study information and contacts of project staff (private WeChat account number and telephone number). Interested participants were asked to contact CBO staff either using private WeChat messages or telephone calls. CBO staff screened prospective participants using the eligibility criteria, introduced the study purpose and procedures, answered questions, and explained the confidentiality of study participation. Participation in this study was voluntary, and participants could refuse to answer any of the questions and withdraw from the study at any time without any consequences. Participants signed an electronic consent form sent via WeChat messages. A link to access an online self-administered questionnaire was sent to the consented participants.

The survey was carried out through Golden Data, a commonly used, encrypted web-based survey platform in China. Each individual WeChat account was allowed to access the online questionnaire only once to avoid duplicate responses. The Golden Data tool performed completeness check before the questionnaire was submitted. Participants could review and change their responses when they completed the questionnaire. The survey took about 13-15 minutes to complete. An electronic coupon with a value of 20 Chinese yuan (3.1 US dollar) was sent to the participant upon the completion of a survey. A unique ID was assigned to each participant, which was to delink the study database from personal identifying data. All data collected by online survey were stored in the Golden Data server and protected by a password. Only the designated research team members had access to the database. Signed electronic consent forms were kept separately from the empirical data and stored in a password-protected computer or a locked cabinet in the same locked office. The Institutional Review Boards of Changzhi Medical College (RT2021003) approved this study.

Measurements

Development of the questionnaire

A panel consisting of public health researchers, health psychologists, clinicians, CBO staff, and PLWHA was formed to develop the questionnaire used in the current study. The panel revised and finalized the questionnaire based on a pilot testing among 10 PLWHA. These 10 PLWHA did not participate in the actual survey.

Background characteristics

Participants reported socio-demographics characteristics, lifestyles (smoking and alcohol drinking), height and weight, and history of other vaccination in the past three years. Participants were also asked whether they had any chronic conditions, such as chronic cardiovascular, respiratory, kidney, and liver diseases, hypertension, diabetes mellitus and its chronic complications, cancers, lymphoma, leukemia, autoimmune diseases, hemorrhagic diseases, and history of severe allergy. The survey also collected some characteristics related to HIV infection (e.g., time since HIV diagnosis, whether they were on antiretroviral therapy (ART), HIV viral load and CD4+ T cell count in the most recent episode of testing, and self-reported severity of AIDS-related symptoms).

Willingness to receive COVID-19 vaccination

Participants were asked about their likelihood of receiving free COVID-19 vaccination in the future (response categories: 1=very unlikely, 2=unlikely, 3=neutral, 4=likely, and 5=very likely). This study defined willingness to receive COVID-19 vaccination as the responses ‘likely’ or ‘very likely’ [27].

Socio-structural-, individual-, and interpersonal-level variables related to COVID-19 vaccination

The research team interviewed CDC staff who were responsible for implementing COVID-19 vaccination program about whether individuals were allowed to make an appointment to receive COVID-19 vaccination and whether there was a shortage in COVID-19 vaccines during the project period in different study sites. Participants were asked whether they belonged to any of the priority groups to received COVID-19 vaccination listed by the National Health Commission during the

project period.

At the individual-level, four scales were constructed to measure perceptions related to COVID-19 vaccination. They were: 1) the five-item Positive Attitude Scale, 2) the five-item Negative Attitude Scale, 3) the four-item Perceived Subjective Norm Scale (i.e., whether significant others would support them to receive COVID-19 vaccination), and 4) the five-item Perceived Behavioral Control Scale (i.e., how much control PLWHA have for receiving COVID-19 vaccination) (response categories: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, & 5=strongly agree). Positive and negative attitudes, perceived subjective norm, and perceived behavioral control were significantly associated with willingness to receive COVID-19 vaccination among Chinese people [27].

For interpersonal-level variables, participants were asked whether they received advices given by doctors, CBO staff, friends and family members, and other PLWHA regarding COVID-19 vaccination. Participants were also asked the overall opinion regarding COVID-19 vaccination they found on Internet or social media (responses categories: 1=against taking up COVID-19 vaccination, 2=no advice/neutral, and 3=supportive to take up COVID-19 vaccination).

Statistical analysis

Using willingness to receive COVID-19 vaccination as the dependent variable and background characteristics as independent variables, crude odds ratios (cOR) were obtained by logistic regression models. After adjusting for variables with $P<0.05$ in the univariate analysis, associations between independent variables of interest (i.e., individual-, interpersonal- and socio-structural-level variables) and the dependent variable were then assessed by adjusted OR (aOR) and 95% Confidence Interval (CI). Each aOR was obtained by fitting a single logistic regression model, which involved one of the independent variables of interest and all significant background characteristics.

Path analysis was conducted to test the mediation model. The means of the Positive Attitude Scale, the Negative Attitude Scale, Subjective Norm Scale and Perceived Behavioral Control Scale

were used as indicators to represent the latent variable of perceptions related to COVID-19 vaccination. The means of advices given by doctors, CBO staff, friends and/or family members, and other PLWHA, as well as overall opinion on the Internet/social media were used as indicators to represent the latent variable of interpersonal-level variables. Confirmatory factor analysis was conducted to test goodness of fit of these constructs. The latent variable representing perceptions was used as independent variable, and willingness to receive COVID-19 vaccination was used as dependent variable. The significant background characteristics were controlled for the model. Goodness of fit was tested by using the Chi-square tests, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Means Square Error of Approximation (RMSEA). Standardized path coefficients (β) and unstandardized path coefficients (B) were reported. The asymmetric confidence intervals (CI) based on bootstrap method (10000 times) were used for significance testing of mediation hypotheses with the 95% bootstrap CI did not include zero indicating a statistically significant mediation effect. Level of statistical significance was set at P=0.05. SPSS 21.0 for Windows and Mplus 8.3 were used for all analyses.

Results

Background characteristics

The CBO approached 10,845 PLWHA in their WeChat groups, 8,692 accessed the online survey, 2,740 completed the survey, and 170 received at least one dose of COVID-19 vaccination at the time of the survey. This study was based on 2,570 eligible participants who had never received COVID-19 vaccination (A flowchart of this study was presented in Figure 2).

The majority of the participants were 18-39 years (74.6%), identified themselves as male (81.9%), were currently single (68.1%), had a full-time job (69.3%), and only had basic health insurance (75.0%). Regarding characteristics related to HIV infection, 17.3% of the participants received their diagnosis within one year, 97.4% were on ART, 67.9% reported undetectable viral load, and 46.0% reported their CD4 cell count level was above 500/μl. Less than 5% self-reported

having severe AIDS-related symptoms. (Table 1 & 2)

Table 1. Socio-demographic characteristics of 2570 unvaccinated participants living with HIV/AIDS in eight Chinese cities

	All participants (n=2570)	Willing to receive COVID-19 vaccination (n=1470)	Unwilling to receive COVID-19 vaccination (n=1100)	Willing versus Unwilling cOR (95%CI)	*P* values
	N (%)	N (%)	N (%)		
Age group, years					
18-29	791 (30.8)	456 (31.0)	335 (30.5)	1.0	Ref
30-39	1125 (43.8)	638 (43.4)	487 (44.3)	0.96 (0.80, 1.16)	.68
40-49	475 (18.5)	287 (19.5)	188 (17.1)	1.12 (0.89, 1.41)	.33
50 or above	179 (7.0)	89 (6.1)	90 (8.2)	0.73 (0.53, 1.01)	.054
Gender at birth					
Male	2431 (94.6)	1390 (94.6)	1041 (94.6)	1.0	Ref
Female	139 (5.4)	80 (5.4)	59 (5.4)	1.02 (0.72, 1.44)	.93
Gender identity					
Male	2106 (81.9)	1224 (83.3)	882 (80.2)	1.0	Ref
Female	228 (8.9)	127 (8.6)	101 (9.2)	0.91 (0.69, 1.19)	.48
Transgender	228 (8.9)	114 (7.8)	114 (10.4)	0.72 (0.55, 0.95)	.02
Others	8 (0.3)	5 (0.3)	3 (0.3)	1.20 (0.29, 5.04)	.80
Relationship status					
Currently single	1750 (68.1)	993 (67.6)	757 (68.8)	1.0	Ref
Cohabited/married with a same-sex partner	377 (14.7)	217 (14.8)	160 (14.5)	1.03 (0.83, 1.30)	.77
Cohabited/married with an opposite-sex partner	443 (17.2)	260 (17.7)	183 (16.6)	1.08 (0.88, 1.34)	.46
Highest education level attained					
Junior high or below	425 (16.5)	249 (16.9)	176 (16.0)	1.0	Ref
Senior high or equivalent	574 (22.3)	319 (21.7)	255 (23.2)	0.88 (0.69, 1.14)	.34
College and above	1571 (61.1)	902 (61.4)	669 (60.8)	0.95 (0.77, 1.18)	.66
Employment status					
Full-time	1782 (69.3)	1022 (69.5)	760 (69.1)	1.0	Ref
Part-time /unemployed/ retired/students/ others	788 (30.7)	448 (30.5)	340 (30.9)	0.98 (0.83, 1.16)	.81
Monthly personal income, Chinese yuan (US dollar)					
No fixed income	302 (11.8)	174 (11.8)	128 (11.8)	1.0	Ref
Below 1,000 (154)	136 (5.3)	72 (4.9)	64 (5.8)	0.83 (0.55, 1.24)	.36
1,000 to 2,999	338 (13.2)	199 (13.5)	139 (12.6)	1.05 (0.77, 1.44)	.75

(154-462)					
3,000 to 4,999 (462-770)	736 (28.6)	413 (28.1)	323 (29.4)	0.94 (0.72, 1.23)	.66
5,000 to 6,999 (770-1,078)	492 (19.1)	285 (19.4)	207 (18.8)	1.01 (0.76, 1.35)	.93
7,000 to 9,999 (1,078-1,540)	273 (10.6)	174 (11.8)	99 (9.0)	1.29 (0.92, 1.81)	.13
At least 10,000 (1,540)	293 (11.4)	153 (10.4)	140 (12.7)	0.80 (0.58, 1.11)	.19
Type of health insurance					
No	307 (11.9)	166 (11.3)	141 (12.8)	1.0	Ref
Basic health insurance only	1927 (75.0)	1111 (75.6)	816 (74.2)	1.16 (0.91, 1.47)	.24
Commercial health insurance only	69 (2.7)	47 (3.2)	22 (2.0)	1.82 (1.04, 3.16)	.04
Both basic and commercial health insurance	253 (9.8)	140 (9.5)	113 (10.3)	1.05 (0.75, 1.47)	.77
Others	14 (0.5)	6 (0.4)	8 (0.7)	0.64 (0.22, 1.88)	.41

cOR: crude odds ratios

Table 2. Lifestyle and health conditions of 2570 unvaccinated participants living with HIV/AIDS in eight Chinese cities

	All participants (n=2570)	Willing to receive COVID-19 vaccination (n=1470)	Unwilling to receive COVID-19 vaccination (n=1100)	Willing versus Unwilling	*P* values
	N (%)	N (%)	N (%)	cOR (95%CI)	
Current smokers					
No	1855 (72.2)	1069 (72.7)	786 (71.5)	1.0	Ref
Yes	715 (27.8)	401 (27.3)	314 (28.5)	0.94 (0.79, 1.12)	.48
Current drinkers					
No	2068 (80.5)	1190 (81.0)	878 (79.8)	1.0	Ref
Yes	502 (19.5)	280 (19.0)	222 (20.2)	0.93 (0.77, 1.13)	.47
Self-reported BMI, kg/m²					
<18.5	235 (9.1)	125 (8.5)	110 (10.0)	1.0	Ref
18.5-23.9	1649 (64.2)	944 (64.2)	705 (64.1)	1.18 (0.90, 1.55)	.24
24.0-27.9	558 (21.7)	327 (22.2)	231 (21.0)	1.25 (0.92, 1.69)	.16
≥28	127 (4.9)	74 (5.0)	53 (4.8)	1.23 (0.80, 1.90)	.36
Presence of chronic disease conditions					
No	1707 (66.4)	1009 (68.6)	698 (63.5)	1.0	Ref
Yes	863 (33.6)	461 (31.4)	402 (36.5)	0.79 (0.67, 0.94)	.01
Medication use for treating chronic diseases					
No	2411 (93.8)	1385 (94.2)	1026 (93.3)	1.0	Ref

Yes	159 (6.2)	85 (5.8)	74 (6.7)	0.85 (0.62, 1.17)	.33
History of other vaccinations in the past three years					
No	2002 (77.9)	1110 (75.5)	892 (81.1)	1.0	Ref
Yes	568 (22.1)	360 (24.5)	208 (18.9)	1.39 (1.15, 1.69)	.001
Time since HIV diagnosis, years					
≤1	443 (17.2)	264 (18.0)	179 (16.3)	1.0	Ref
2-5	1198 (46.6)	685 (46.6)	513 (46.6)	0.91 (0.73, 1.13)	.38
>5	929 (36.1)	521 (35.4)	408 (37.1)	0.87 (0.69, 1.09)	.22
On antiretroviral therapy (ART)					
No	69 (2.7)	40 (2.7)	29 (2.6)	1.0	Ref
Yes	2501 (97.3)	1430 (97.3)	1071 (97.4)	0.97 (0.60, 1.57)	.90
HIV viral load in the most recent episode of testing, copies/ml					
Undetectable (<50)	1746 (67.9)	988 (67.2)	758 (68.9)	1.0	Ref
50-200	154 (6.0)	79 (5.4)	75 (6.8)	0.81 (0.58, 1.12)	.21
201-400	69 (2.7)	45 (3.1)	24 (2.2)	1.44 (0.87, 2.38)	.16
>400	137 (5.3)	87 (5.9)	50 (4.5)	1.34 (0.93, 1.91)	.12
Not sure	464 (18.1)	271 (18.4)	193 (17.5)	1.08 (0.88, 1.33)	.48
CD4+ T cell count in the most recent episode of testing, cells/mm^3					
>500	1181 (46.0)	669 (45.5)	512 (46.5)	1.0	Ref
350-499	531 (20.7)	320 (21.8)	211 (19.2)	1.16 (0.94, 1.43)	.16
200-349	258 (10.0)	150 (10.2)	108 (9.8)	1.06 (0.81, 1.40)	.66
<200	89 (3.5)	44 (3.0)	45 (4.1)	0.75 (0.49, 1.15)	.19
Unknown	511 (19.9)	287 (19.5)	224 (20.4)	0.98 (0.80, 1.21)	.85
Self-reported severity of AIDS-related symptoms					
No symptom	1306 (50.8)	767 (52.2)	539 (49.0)	1.0	Ref
Mild	839 (32.6)	483 (32.9)	356 (32.4)	0.95 (0.80, 1.14)	.60
Moderate	308 (12.0)	157 (10.7)	151 (13.7)	0.73 (0.57, 0.94)	.01
Severe	117 (4.6)	63 (4.3)	54 (4.9)	0.82 (0.56, 1.20)	.31

cOR: crude odds ratios

Willingness to receive COVID-19 vaccination and individual-, interpersonal- and socio-structural-level variables

Over half of the participants were willing to receive free COVID-19 vaccination in the future (57.2%, 1,470/2,570). A shortage of COVID-19 vaccine was encountered in Shenyang, Guangzhou, and Shenzhen. Among the participants, 19.0% identified themselves as priority groups to receive

COVID-19 vaccination. The Cronbach's alpha of the scales on perceptions related to COVID-19 vaccination ranged from 0.83 to 0.92, single factors were identified by exploratory factor analysis, explaining for 61.1-76.4% of total variance. (Table 3 and Multimedia Appendix 1)

Table 3. Willingness to receive COVID-19 vaccination, and socio-structural, individual and interpersonal variables among 2570 unvaccinated participants living with HIV/AIDS

	All participants (n=2570)	Willing to receive COVID-19 vaccination (n=1470)	Unwilling to receive COVID-19 vaccination (n=1100)	Willing versus Unwilling	*P* values
	N (%)	N (%)	N (%)	cOR (95%CI)	
Willingness to receive free COVID-19 vaccination					
No (very unlikely/ unlikely/neutral)	1100 (42.8)				
Yes (likely/very likely)	1470 (57.2)	N.A.	N.A.	N.A.	N.A.
Socio-structural-level variables					
Individuals could make an appointment to receive COVID-19 vaccination during the study period					
No	1578 (61.4)	887 (60.3)	691 (62.8)	1.0	Ref
Yes	992 (38.6)	583 (39.7)	409 (37.2)	1.11 (0.95, 1.30)	.20
There was a shortage of COVID-19 vaccine in the city where the participants were living during the study period					
No	1729 (67.3)	1009 (68.6)	720 (65.5)	1.0	Ref
Yes	841 (32.7)	461 (31.4)	380 (34.5)	0.87 (0.73, 1.02)	0.09
Whether participants belonged to any priority groups to receive COVID-19 vaccination in their cities during the study period					
No	2082 (81.0)	1189 (80.9)	893 (81.2)	1.0	Ref
Yes	488 (19.0)	281 (19.1)	207 (18.8)	1.02 (0.84, 1.25)	.85
Perceptions and					

attitudes toward COVID-19 vaccination (Individual-level variables)					
Positive Attitude Scale [a], mean (SD)	18.4 (4.8)	19.3 (4.6)	17.1 (4.7)	1.11 (1.09, 1.13)	<.001
Negative Attitude Scale [b], mean (SD)	18.6 (5.2)	18.1 (5.4)	19.3 (4.8)	0.96 (0.94, 0.97)	<.001
Perceived Subjective Norm Scale [c], mean (SD)	13.3 (2.4)	14.5 (2.5)	12.3 (1.8)	1.53 (1.46, 1.61)	<.001
Perceived Behavioral Control Scale [d], mean (SD)	12.9 (6.1)	14.7 (6.1)	10.6 (5.4)	1.13 (1.11, 1.14)	<.001
Interpersonal-level variables					
Advice from doctors regarding COVID-19 vaccination					
Mean (SD)	2.1 (0.5)	2.2 (0.5)	2.0 (0.4)	2.03 (1.69, 2.44)	<.001
Advices from CBO staff regarding COVID-19 vaccination					
Mean (SD)	2.1 (0.4)	2.1 (0.4)	2.0 (0.4)	1.86 (1.49, 2.32)	<.001
Advices from friends and family members regarding COVID-19 vaccination					
Mean (SD)	2.0 (0.2)	2.0 (0.4)	1.9 (0.2)	3.18 (1.92, 5.26)	<.001
Advices from other PLWHA regarding COVID-19 vaccination					
Mean (SD)	2.0 (0.3)	2.1 (0.3)	1.9 (0.4)	2.38 (1.85, 3.07)	<.001
Overall opinion regarding COVID-19 vaccination for PLWHA on Internet/social media					
Mean (SD)	2.0 (0.4)	2.1 (0.4)	2.0 (0.4)	1.63 (1.34, 1.98)	<.001

SD, standard deviation·

[a] Positive Attitude Scale, 5 items, maximum value = 25; Cronbach's alpha: 0.83, one factor was identified by exploratory factor analysis, explaining for 61.1% of total variance

[b] Negative Attitude Scale, 5 items, maximum value = 25; Cronbach's alpha: 0.87, one factor was identified by exploratory factor analysis, explaining for 66.3% of total variance

[c] Perceived Subjective Norm Scale, 4 items, maximum value = 20; Cronbach's alpha: 0.84, one factor was identified by exploratory factor analysis, explaining for 63.4% of total variance

[d] Perceived Behavioral Control Scale, 5 items, maximum value = 25; Cronbach's alpha: 0.92, one

factor was identified by exploratory factor analysis, explaining for 76.4% of total variance

Factors associated with willingness to receive COVID-19 vaccination

In the univariate logistic regression analysis, transgender person, and those with chronic conditions and severer AIDS-related symptoms showed lower willingness to receive COVID-19 vaccination. Having commercial health insurance only and history of other vaccination in the past three years were associated with higher willingness to receive COVID-19 vaccination. (Table 1 & 2)

After adjusting for significant background characteristics, having more positive attitudes towards COVID-19 vaccination (aOR: 1.11, 95%CI: 1.09, 1.12, *P*<.001), perceived stronger support from significant others (perceived subjective norm) (aOR: 1.53, 95%CI: 1.46, 1.61, *P*<.001), and perceived higher behavioral control (aOR: 1.13, 95%CI: 1.11, 1.14, *P*<.001) to take up the vaccination were associated with higher willingness to receive COVID-19 vaccination. A negative association was found between negative attitudes towards COVID-19 vaccination and the dependent variable (aOR: 0.96, 95%CI: 0.94, 0.97, *P*<.001). At the interpersonal-level, receiving advices supportive of COVID-19 vaccination from doctors (aOR: 1.99, 95%CI: 1.65, 2.40, *P*<.001), CBO staff (aOR: 1.89, 95%CI: 1.51, 2.36, *P*<.001), friends and family members (aOR: 3.22, 95%CI: 1.93, 5.35, *P*<.001), and other PLWHA (aOR: 2.38, 95%CI: 1.85, 3.08, *P*<.001) were associated with higher willingness to receive COVID-19 vaccination. Overall opinion supporting COVID-19 vaccination for PLWHA on Internet/social media was also positively associated with the dependent variable (aOR: 1.59, 95%CI: 1.31, 1.94, *P*<.001). (Table 4)

Table 4 Factors associated with willingness to receive COVID-19 vaccination among 2570 unvaccinated participants living with HIV/AIDS

	aOR (95%CI)	*P* values
Socio-structural-level variables		
Individuals could make an appointment to receive COVID-19 vaccination during the study period		
No		
Yes	---	---
There was a shortage of COVID-19 vaccines in the city where the participants is living during the study period		
No		

Yes	---	---
Whether participants belonged to priority groups to receive COVID-19 vaccination in the city where they are living		
No		
Yes	---	---
Individual-level variables		
Positive Attitude Scale	1.11 (1.09, 1.12)	<.001
Negative Attitude Scale	0.96 (0.94, 0.97)	<.001
Perceived Subjective Norm Scale	1.53 (1.46, 1.61)	<.001
Perceived Behavioral Control Scale	1.13 (1.11, 1.14)	<.001
Interpersonal-level variables		
Advices from doctors regarding COVID-19 vaccination	1.99 (1.65, 2.40)	<.001
Advices from CBO staff regarding COVID-19 vaccination	1.89 (1.51, 2.36)	<.001
Advices from friends and family members regarding COVID-19 vaccination	3.22 (1.93, 5.35)	<.001
Advices from other PLWHA regarding COVID-19 vaccination	2.38 (1.85, 3.08)	<.001
Overall opinion regarding COVID-19 vaccination for PLWHA on Internet/social media	1.59 (1.31, 1.94)	<.001

aOR: adjusted odds ratios, odds ratios obtained by fitting a single logistic regression model involving an independent variable of interest and all background variables listed in Table 1 & 2 with p<0·05 in univariate analysis;
---: P>0·05 in univariate analysis and not considered by the multivariate analysis.

Testing the mediation effects of perceptions in the association between interpersonal-level variables and willingness to receive COVID-19 vaccination

Model testing

Confirmative factor analysis showed perceptions fit the data well (CFI=0.98, TLI=0.90, RMSEA=0.08). All the factor loadings were significant at *P*<.001, with β ranged from 0.23 to 0.73. The interpersonal-level variables also fit the data well (CFI=0.98, TLI=0.97, RMSEA=0.02). All the factor loadings were significant at p<.001, with standardized coefficients ranged from 0.27 to 0.50. The hypothesized mediation model showed good fit to the data (CFI=0.96, TLI=0.94, RMSEA=0.03)

Path coefficients

Path analysis showed that interpersonal-level variables were positively associated with perceptions (B=4.72, β=0.57, *P*<.001); while its association with willingness to receive COVID-19 vaccination was non-significant (B=-0.28, β=-0.06, *P*=0.23). Perceptions were positively associated with willingness to receive COVID-19 vaccination (B=0.43, β=0.74, *P*<.001). (Figure 3)

Mediation effects

Bootstrap analysis showed that interpersonal-level variables (B=2.01, 95% CI=1.67, 2.53; β=0.43, 95% CI=0.37, 0.51; *P*<.001) was indirectly associated with willingness to receive COVID-19 vaccination via perceptions. Perceptions fully mediated the association between interpersonal-level variables and willingness to receive COVID-19 vaccination.

Discussion

Knowing the willingness to receive COVID-19 vaccination among PLWHA is essential in the scale-up of COVID-19 vaccination among this group. The finding represents the latest estimate of willingness to receive COVID-19 vaccination among PLWHA in China and can be used to project future vaccine uptake in this group. This study extended the existing literature by conducting the study in multiple cities in different geographic regions of China, with large sample size, and examined the multiple-level factors correlated with the willingness.

We found the level of willingness among our participants was relatively low (less than 60%). Such level was lower than that of PLWHA in France and the United States and the general population in most parts of the world [19] and China (70-90%) [26, 27]. Since there is a gap between willingness and the actual uptake, the COVID-19 vaccination coverage among PLWHA would be even lower without effective interventions [32]. The above findings revealed the COVID-19 vaccination hesitancy and highlighted a strong need to promote COVID-19 vaccination among PLWHA.

This study examined associated factors at all three levels suggested by the socio-ecological model, the findings could inform tailored interventions promoting COVID-19 vaccination among

PLWHA. It firstly demonstrated that the individual-level variables (perceptions related to COVID-19 vaccination) and interpersonal-level variables (advices from others and information exposure on Internet/social media) were determinants of willingness among PLWHA. The findings extended the application of the socio-ecological model. More importantly, this study examined the potential mechanism of the associations between interpersonal interactions and willingness to receive COVID-19 vaccination. The results suggested that exposure to advices/information supporting PLWHA to receive COVID-19 vaccination might enhance perceptions favoring COVID-19 vaccination, which in turn increase their willingness to receive such vaccination. The significant mediation effect supported the mechanism proposed by the Social Learning Theory [33].

This study also had numerous practical implications to develop tailored vaccination strategies for PLWHA. First, more attention should be given to PLWHA who were transgender persons, with chronic conditions, and having severe AIDS-related symptoms, as these sub-groups reported lower willingness. Transgender people are often marginalized, encountering difficulties to access healthcare services [34]. Future program targeting PLWHA should consider including transgender friendly vaccination services. Having AIDS-related symptoms was also associated with lower willingness. Since official opinions in China stated that effectiveness of COVID-19 vaccination was lower for people with immunodeficiency [18], PLWHA might think that they could not benefit from COVID-19 vaccination. Health communication messages should clearly state that PLWHA are recommended to receive COVID-19 vaccination if their chronic conditions are stable, regardless of AIDS-related symptoms.

Second, modifying perceptions related to COVID-19 vaccination is potentially useful in health promotion, as they were significantly associated with willingness in expected directions. It is useful to increase positive attitudes toward COVID-19 vaccination, as it was a facilitator. Health communication messages should emphasize the physical and psychological benefits of COVID-19 vaccination. About half of the participants had concerns related to side effects, exposing PLWHA

identity, and potential interactions between COVID-19 vaccines and HIV/ART. Having more concerns was associated with lower willingness. Testimonials on positive experiences shared by vaccinated PLWHA might be useful to reduce their concerns related to side effects and privacy. Health communication messages should also emphasize no evidence showing that ART and COVID-19 vaccination would have negative impact on each other [35]. Less than 40% of the participants perceived medical professionals, CBO staff, family members and friends would support them to take up COVID-19 vaccination. Such perception was also a facilitator. Future program should consider involving these significant others of PLWHA to create a subjective norm favoring COVID-19 vaccination uptake. It is also useful to enhance perceived behavioral control, as it was another facilitator. There is much room for improvement. Facilitating PLWHA to form a plan to receive COVID-19 vaccination may be helpful to improve perceived behavioral control.

Third, the significant mediation effect of perceptions in the association between interpersonal-level variables and willingness to receive COVID-19 vaccination suggested that future programs should involve clinical doctors, CBO staff, family members/friends, and PLWHA peers to give supportive advices. Health authorities should also disseminate clear recommendation for PLWHA to receive COVID-19 vaccination through official online channels, which are considered as influential and credible sources by Chinese people [36]. These strategies may be useful to modify PLWHA's perceptions and in turn increase their willingness to receive COVID-19 vaccination.

This study also had some limitations. First, policies and guidelines related to COVID-19 vaccination are changing rapidly. Our findings are most applicable to the early phase of COVID-19 vaccination implementation in China. Second, participants were recruited in large Chinese cities. Generalizations should be made cautiously to PLWHA living in smaller cities or counties in China. Third, we were not able to collect information from PLWHA who refused to participate in the study. PLWHA who refused to complete the survey may have different characteristics from the participants. Selection bias existed. Fourth, most items and scales used in this study were self-constructed based

on those used in the general population. The internal validity of these scales was acceptable. However, external validation data were seldom available. Fifth, it was a limitation that we did not ask whether participants anticipated or have experienced challenges in making an appointment to receive the COVID-19 vaccine. The procedures to make an appointment are easy. Most Chinese people did not encounter difficulties when they were using the appointment system. We believed the impact of anticipated/experienced challenges on PLWHA's willingness to receive COVID-19 vaccination would be limited. Sixth, we did not study PLWHA's preference toward different types of COVID-19 vaccines. Although inactivated vaccines were the only available COVID-19 vaccines in China during the study period, it is worthwhile to look at their preference toward other types of vaccines (e.g., mRNA or adenovirus vector vaccines) [37]. Moreover, selection of the timeframe for history of other vaccination (past 3 years) was arbitrary. Furthermore, causality could not be established, as this was a cross-sectional study.

Conclusions

In sum, PLWHA in China reported a relatively low willingness to receive COVID-19 vaccination comparing to PLWHA in other countries and general population in most part of the world. Perceptions related to COVID-19 vaccination and interpersonal-level variables such as receiving advices from others or information exposure through Internet/social media were determinants of willingness. Information exposure on Internet/social media and interpersonal communications with doctors, CBO staff, friends, family members and other PLWHA may be major sources of influence on PLWHA's perceptions and willingness to receive COVID-19 vaccination. The study findings could be used to design tailored interventions with the aims to improve vaccination coverage and reduce risks of COVID-19 among PLWHA.

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Authors' contributions

Conceptualization: W.T., Z.W., J.X.; Methodology: H.Z.Q., W.T., J.X.; Data curation: X.H., M.Y., G.F., G.L., L.L., J.Y., Y.Q., J.Z.; Formal analysis: Z.W., H.J.; Project administration: X.H., M.Y., G.F., G.L., L.L., J.Y., Y.Q., J.Z., X.Z., X.J., G.C., J.X.; Resources: X.H., M.Y., G.F., G.L., L.L., J.Y., Y.Q., J.Z., J.X., X.Z., X.J., G.C.,; Supervision: J.X., Writing-original draft preparation: Z.W., H.J., J.X.; Writing-review and editing: H.Z.Q., W.T., Z.W., J.X; Funding acquisition: J.X. All authors have read and agreed to the manuscript.

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Ethics approval and consent to participate

Informed consent was obtained from all subjects involving in the study. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Boards of Changzhi Medical College (protocol code: RT2021003).

Competing interests

The authors declare that they have no competing interests. The sponsors had no role in the design, execution, interpretation, or writing of the study.

List of abbreviations

aOR: Adjusted Odds Ratios

B: Unstandardized Path Coefficients

β: Standardized path coefficients

CBO: Community-based Organizations

CFI: Comparative Fit Index

CI: Confidence Interval

cOR: Crude Odds Ratios

PLWHA: People Living with HIV and AIDS

RMSEA: Root Means Square Error of Approximation

TLI: Tucker-Lewis Index

TPB: Theory of Planned Behavior

WHO: World Health Organization

Multimedia appendix 1

Frequency distribution of items measuring individual-level and interpersonal-level variables

References

1. World Health Organization. Coronavirus disease (COVID-19): COVID-19 vaccines and people living with HIV. Retrieved from: https://www.who.int/news-room/q-a-detail/coronavirus-disease-(covid-19)-covid-19-vaccines-and-people-living-with-hiv. Accessed on August 19, 2021.
2. Bartsch SM, O'Shea KJ, Ferguson MC, Bottazzi ME, Wedlock PT, Strych U, et al. Vaccine Efficacy Needed for a COVID-19 Coronavirus Vaccine to Prevent or Stop an Epidemic as the Sole Intervention. American journal of preventive medicine. 2020;59(4):493-503.
3. Polack FP, Thomas SJ, Kitchin N, Absalon J, Gurtman A, Lockhart S, et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. The New England journal of medicine. 2020;383(27):2603-15.
4. Voysey M, Clemens SAC, Madhi SA, Weckx LY, Folegatti PM, Aley PK, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet. 2021;397(10269):99-111.
5. Baden LR, El Sahly HM, Essink B, Kotloff K, Frey S, Novak R, et al. Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. The New England journal of medicine. 2021;384(5):403-16.
6. Sadoff J, Gray G, Vandebosch A, Cárdenas V, Shukarev G, Grinsztejn B, et al. Safety and Efficacy of Single-Dose Ad26.COV2.S Vaccine against Covid-19. The New England journal of medicine. 2021;384(23):2187-201.
7. Shinde V, Bhikha S, Hoosain Z, Archary M, Bhorat Q, Fairlie L, et al. Efficacy of NVX-CoV2373 Covid-19 Vaccine against the B.1.351 Variant. The New England journal of medicine. 2021;384(20):1899-909.
8. Hosein SR. Encouraging results from the Pfizer-BioNTech COVID-19 vaccine in HIV-positive people. Available at: https://www.catie.ca/en/catienews/2021-05-25/encouraging-results-pfizer-biontech-covid-19-vaccine-hiv-positive-people. Accessed on August 11, 2021. 2021.
9. Ruddy JA, Boyarsky BJ, Bailey JR, Karaba AH, Garonzik-Wang JM, Segev DL, et al. Safety and antibody response to two-dose SARS-CoV-2 messenger RNA vaccination in persons with HIV. Aids. 2021.
10. Woldemeskel BA, Karaba AH, Garliss CC, Beck EJ, Wang KH, Laeyendecker O, et al. The BNT162b2 mRNA Vaccine Elicits Robust Humoral and Cellular Immune Responses in People Living with HIV. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America. 2021.
11. Frater J, Ewer KJ, Ogbe A, Pace M, Adele S, Adland E, et al. Safety and immunogenicity of the ChAdOx1 nCoV-19 (AZD1222) vaccine against SARS-CoV-2 in HIV infection: a single-arm substudy of a phase 2/3 clinical trial. The lancet HIV. 2021;8(8):e474-e85.
12. Madhi S, Koen A, Fairlie L, Cutland C, Ballie V, Padayachee S, et al. ChAdOx1 nCoV-19 (AZD1222) Vaccine in People Living With and Without HIV. Research square preprint. Available at: https://www.researchsquare.com/article/rs-322470/v1. Accessed on August 11, 2021. 2021.
13. United States Department of Health and Human Services. Guidance for COVID-19 and People with HIV. Retrieved from: https://clinicalinfo.hiv.gov/sites/default/files/guidelines/documents/HIV_COVID_19_GL__2021.pdf. Accessed on August 19, 2021.
14. British HIV Association. SARS-CoV-2 vaccine advice for adults living with HIV: British HIV Association (BHIVA) & Terrence Higgins Trust (THT) guidance. Retrieved from: https://www.bhiva.org/SARS-CoV-2-vaccine-advice-for-adults-living-with-HIV-plain-english-version-update. Accessed on August 19, 2021.
15. ASHM COVID-19 Taskforce. Statement from the ASHM COVID-19 Taskforce regarding the prioritization of COVID-19 vaccines for people living with HIV. Retrieved from: https://www.ashm.org.au/covid-19/clinical-care/statement-regarding-the-prioritisation-of-covid-19-vaccines/. Accessed on August 19, 2021.
16. Centers for Disease Control and Prevention (CDC). COVID-19 vaccines for moderately to severely immunocompromised people. Retrieved from: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/immuno.html. Accessed on August 19, 2021.
17. Chapter of Infectious Disease Physicians. Consensus statement on the expansion of eligibility for COVID-19 vaccination for people living with HIV in Singapore. Retrieved from: https://www.ams.edu.sg/view-pdf.aspx?file=media%5C6191_fi_641.pdf&ofile=Consensus+statement+-+Expansion+of+Eligibility+for+COVID-

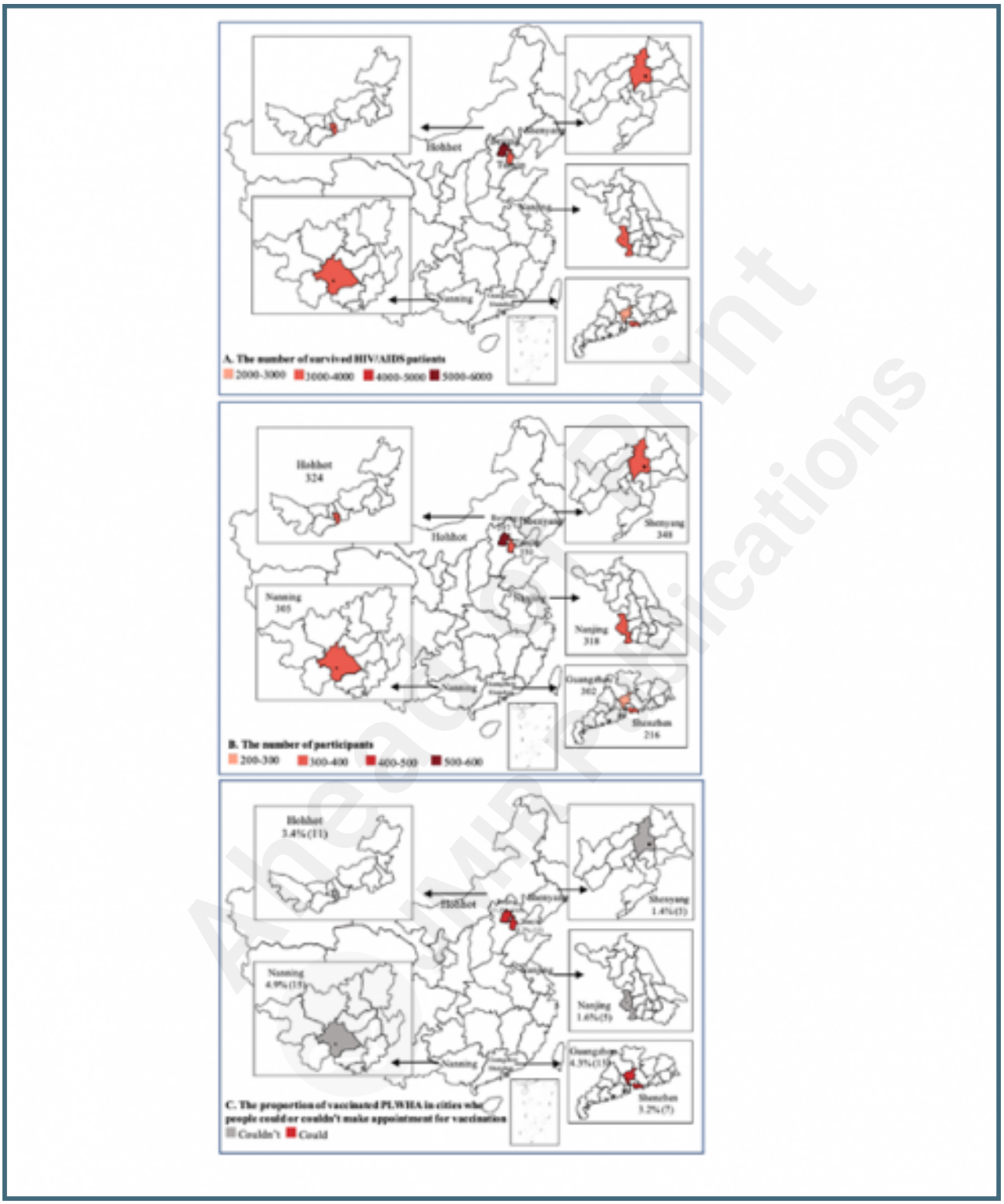
19+Vaccination+for+people+living+with+HIV+in+Singapore+2021+0628.pdf. Accessed on August 19, 2021.
18. National Health Commission of the People's Republic of China. Technical guideline on COVID-19 vaccination (1st Edition). Available at: http://www.nhc.gov.cn/xcs/yqfkdt/202103/c2febfd04fc5498f916b1be080905771.shtml. (accessed March 30, 2021). 2021.
19. Sallam M. COVID-19 Vaccine Hesitancy Worldwide: A Concise Systematic Review of Vaccine Acceptance Rates. Vaccines. 2021;9(2).
20. Group C. A future vaccination campaign against COVID-19 at risk of vaccine hesitancy and politicisation. The Lancet Infectious diseases. 2020;20(7):769-70.
21. Wang Z, She R, Chen X, Li L, Li L, Huang Z, et al. Parental acceptability of COVID-19 vaccination for children under the age of 18 years among Chinese doctors and nurses: a cross-sectional online survey. Human vaccines & immunotherapeutics. 2021:1-11.
22. Vallée A, Fourn E, Majerholc C, Touche P, Zucman D. COVID-19 Vaccine Hesitancy among French People Living with HIV. Vaccines. 2021;9(4).
23. Bogart LM, Ojikutu BO, Tyagi K, Klein DJ, Mutchler MG, Dong L, et al. COVID-19 Related Medical Mistrust, Health Impacts, and Potential Vaccine Hesitancy Among Black Americans Living With HIV. Journal of acquired immune deficiency syndromes. 2021;86(2):200-7.
24. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. Health education quarterly. 1988;15(4):351-77.
25. Pan Y, Fang Y, Xin M, Dong W, Zhou L, Hou Q, et al. Self-Reported Compliance With Personal Preventive Measures Among Chinese Factory Workers at the Beginning of Work Resumption Following the COVID-19 Outbreak: Cross-Sectional Survey Study. Journal of medical Internet research. 2020;22(9):e22457.
26. Wang J, Jing R, Lai X, Zhang H, Lyu Y, Knoll MD, et al. Acceptance of COVID-19 Vaccination during the COVID-19 Pandemic in China. Vaccines. 2020;8(3).
27. Zhang KC, Fang Y, Cao H, Chen H, Hu T, Chen Y, et al. Behavioral Intention to Receive a COVID-19 Vaccination Among Chinese Factory Workers: Cross-sectional Online Survey. Journal of medical Internet research. 2021;23(3):e24673.
28. Wong MCS, Wong ELY, Huang J, Cheung AWL, Law K, Chong MKC, et al. Acceptance of the COVID-19 vaccine based on the health belief model: A population-based survey in Hong Kong. Vaccine. 2021;39(7):1148-56.
29. Wang K, Wong EL, Ho KF, Cheung AW, Yau PS, Dong D, et al. Change of Willingness to Accept COVID-19 Vaccine and Reasons of Vaccine Hesitancy of Working People at Different Waves of Local Epidemic in Hong Kong, China: Repeated Cross-Sectional Surveys. Vaccines. 2021;9(1).
30. Yu Y, Lau JTF, Lau MMC, Wong MCS, Chan PKS. Understanding the Prevalence and Associated Factors of Behavioral Intention of COVID-19 Vaccination Under Specific Scenarios Combining Effectiveness, Safety, and Cost in the Hong Kong Chinese General Population. International journal of health policy and management. 2021.
31. Lau JTF, Wang Z, Kim Y, Li J, Gu J, Mo PKH, et al. Low sustainability, poor governance, and other challenges encountered by grassroots non-governmental organizations targeting HIV prevention for men who have sex with men in China - a nation-wide study. AIDS care. 2017;29(12):1480-90.
32. Michie S, Johnston M, Francis J, Hardeman W, Eccle M. From theory to intervention: mapping theoretically derived behaviorual determinants to behaviour change techniques. . Applied Psychology. 2008;57:660-80.
33. Moreno MA, Whitehill JM. Influence of Social Media on Alcohol Use in Adolescents and Young Adults. Alcohol research : current reviews. 2014;36(1):91-100.
34. Poteat T, Wirtz AL, Radix A, Borquez A, Silva-Santisteban A, Deutsch MB, et al. HIV risk and preventive interventions in transgender women sex workers. Lancet. 2015;385(9964):274-86.
35. UNAIDS. COVID-19 VACCINES AND HIV. Available at: https://www.unaids.org/en/resources/documents/2021/covid19-vaccines-and-hiv. (accessed March 30, 2021). 2021.
36. Pan Y, Xin M, Zhang C, Dong W, Fang Y, Wu W, et al. Associations of Mental Health and Personal

Preventive Measure Compliance With Exposure to COVID-19 Information During Work Resumption Following the COVID-19 Outbreak in China: Cross-Sectional Survey Study. Journal of medical Internet research. 2020;22(10):e22596.
37. Zewude B, Habtegiorgis T. Willingness to Take COVID-19 Vaccine Among People Most at Risk of Exposure in Southern Ethiopia. Pragmatic and observational research. 2021;12:37-47.

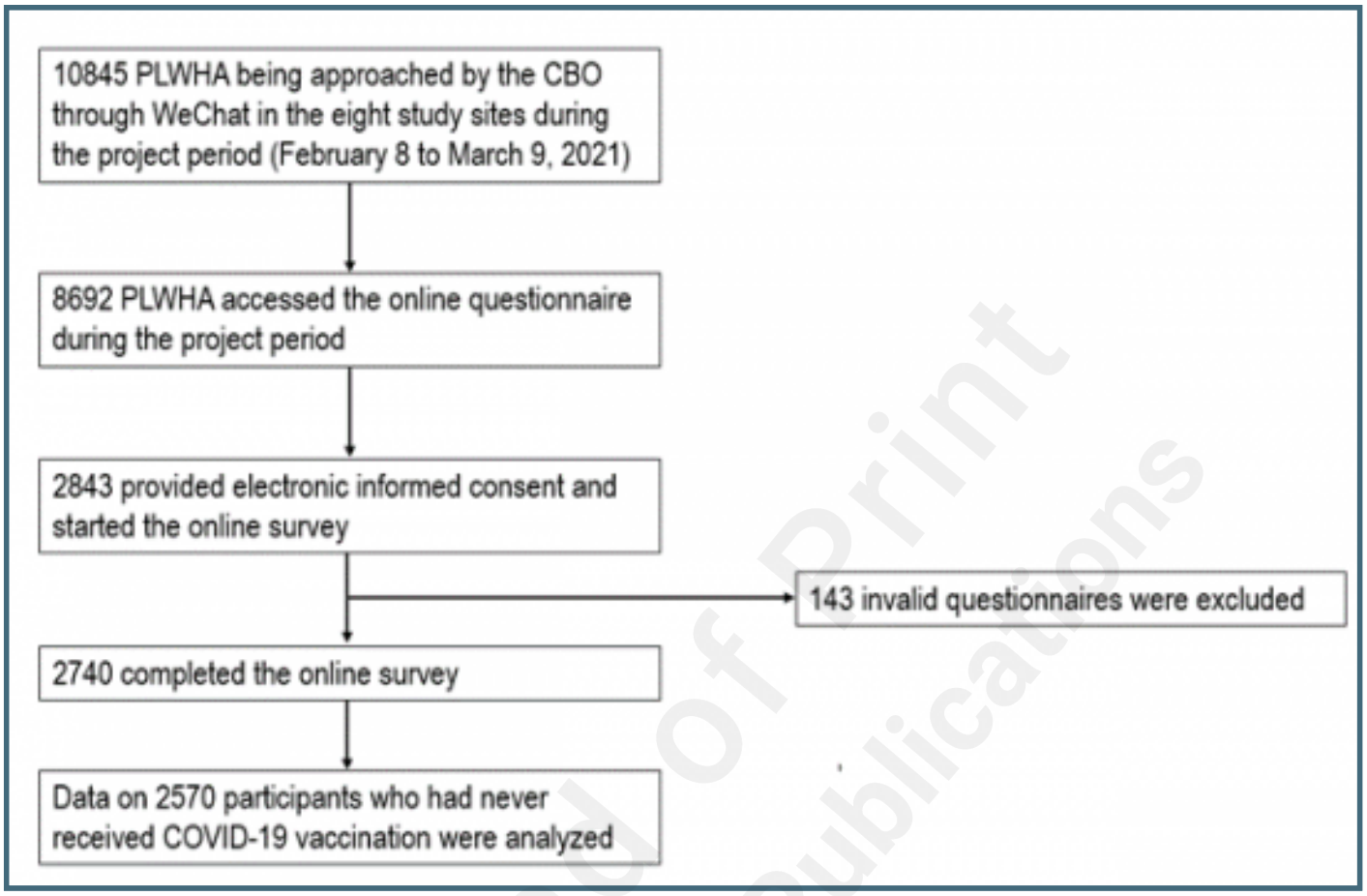
Supplementary Files

Figures

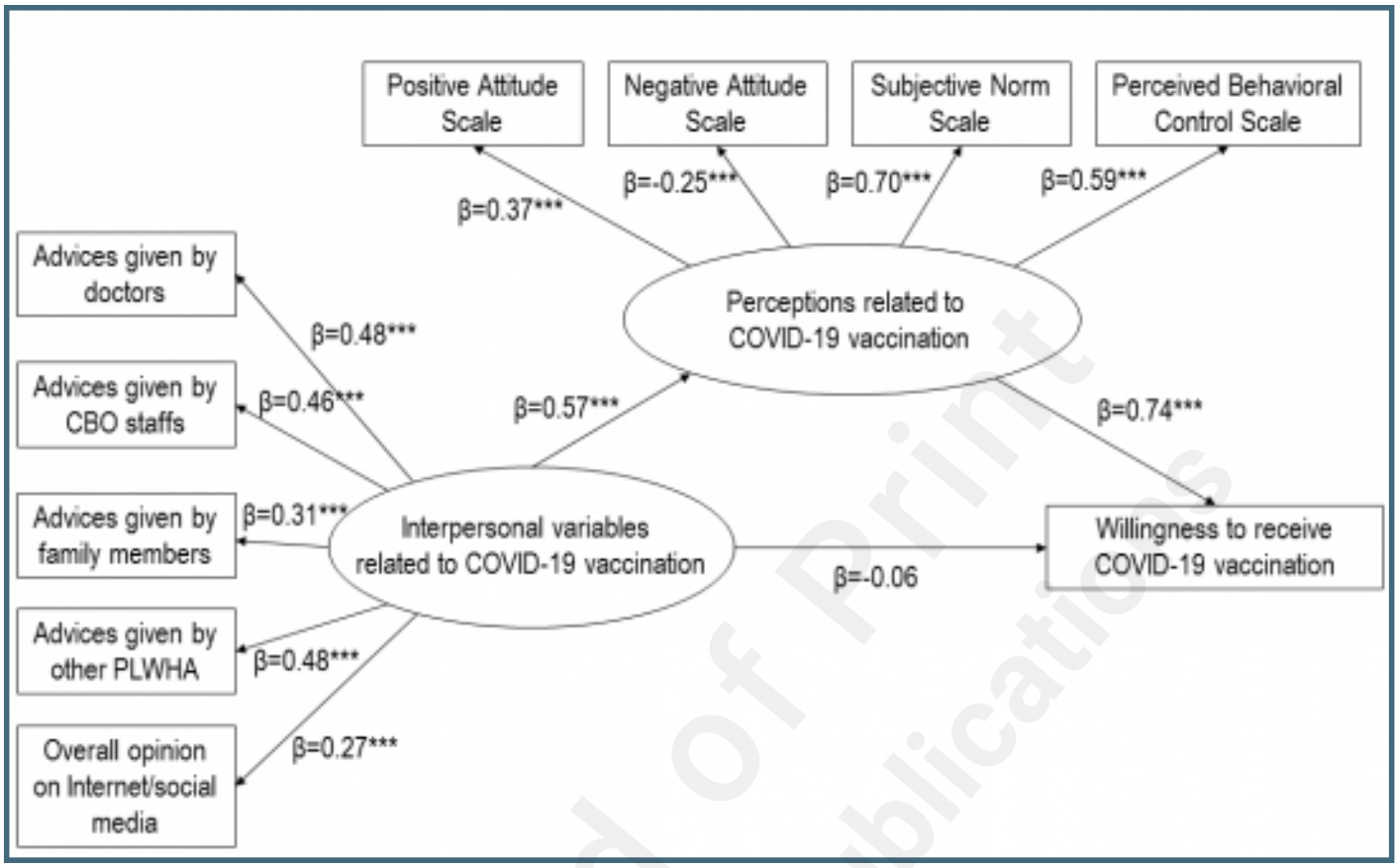
Context of the this study.



Flowchart of data collection.



Mediation model with path coefficients.



Multimedia Appendixes

Frequency distribution of items measuring individual-level and interpersonal-level variables.
URL: http://asset.jmir.pub/assets/2d2e35ced9a2748d606e6a1ed0906bcd.docx