Changes in HIV risk behaviors and testing activity in the context of the COVID 19 pandemic

by

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Abstract

Background

Despite progress in antiretroviral therapy (ART) and the introduction of pre-exposure prophylaxis (PrEP), HIV still remains an issue among key populations in China. Responses tothe COVID 19 pandemic may have affected the provision of regular sexual health services (SHS). On the other hand, high-risk behaviors might also have changed. This study aims to evaluate changes in HIV testing and risk behaviors among men who have sex men during the COVID 19 pandemic.

Methods:

This study is a retrospective cohort of MSM attending free voluntary counselling and testing (VCT) at an NGO in the city of Chengdu, China between 2012 and 2021. Information about their sexual behavior was recorded systematically at each visit, and records were anonymously linked for subjects with multiple visits. Test counts, interval between tests and high-risk behaviors were compared using Poisson, Cox and logistic regression respectively.

Results:

Test counts were lower than previous years in the first half of 2020, but overall, there was no significant effect of the pandemic on quarterly numbers throughout 2020 (IRR=0.79, p=0.2). The interval between two tests was reduced after the start of the pandemic (HR=1.20, p<0.001). Neither the proportion of high number of partners (OR=1.14, p=0.08) or condom use (OR=1.06, p=0.2) were impacted.

Conclusion:

China's choice of a zero-covid policy led to a quick return to normal services, although impacting SHS initially it did not have a long-term negative effect on testing activity. High- risk behavior proportions are also at similar level than pre-pandemic. However, there is still progress to be made to eradicate the HIV epidemic.

Keywords: HIV; China; COVID 19; sexual health services disruption; lockdown; men who have sex with men

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List of abbreviations

AIDS	Acquired immunodeficiency syndrome
ART	Antiretroviral therapy
CDP	Condom distribution program
COVID 19	Coronavirus disease 19
HIV	Human immunodeficiency virus
MSM	Men who have sex with men
NGO	Non-governmental organization
NSP	Needle and syringe program
PLWH	People living with HIV
PrEP	Pre-exposure prophylaxis
PWID	People who inject drugs
SHS	Sexual health services
STI	Sexually transmitted infection
UNAIDS	Joint United Nations Programme on HIV/AIDS
VCT	Voluntary counselling and testing
WHO	World Health Organization

1. Introduction

HIV/AIDS is classified as a global epidemic by the WHO [1]. Although fatal without treatment,with the progress in antiretroviral therapies (ART) the epidemic has become a manageable chronic disease epidemic in most countries. While in some countries in sub-Saharan Africa the HIV epidemic is a generalized epidemic, spreading widely among the heterosexual community, in many countries in Asia it is concentrated in key populations. Key populations for HIV include men who have sex with men (MSM), people who inject drugs (PWID) and sex workers. Strategies to reduce the risk of HIV transmission in these key populations focus on behavioral interventions to reduce behaviors associated with a high risk of transmission, and biomedical strategies. Attaining the correct balance of these prevention strategies is essential to contain the epidemic within these key populations and reduce the burden of HIV.

1.1. HIV prevention and treatment

Behavioral interventions focus mainly on education interventions, particularly among key populations, aiming to increase condom use, reduce the number of sexual partners and reduce needle-sharing, in conjunction with programs to improve condom availability, condom distribution programs (CDPs) and provide sterile injecting equipment through needles and syringes programs (NSPs). These interventions have been shown to be effective in the prevention of HIV [2], but their effectiveness is often reduced by marginalization, stigma and other challenges providing health care to hard-to-reach populations [3].

Biomedical strategies focus on increasing testing behavior, providing early and rapid access to ART. ART can reduce viral load low enough to avoid transmission to partners, and early uptake of ART combined with widespread testing and behavioral change has the potential to eliminate HIV [4]. As a result, voluntary testing and treatment coupled with early entry to treatment is now the mainstay of many prevention strategies in high-income countries, based around the concept of undetectable=untransmittable (U=U) [5]. Figure 1 illustrates the ART treatment cascade globally and its evolution since 2016.

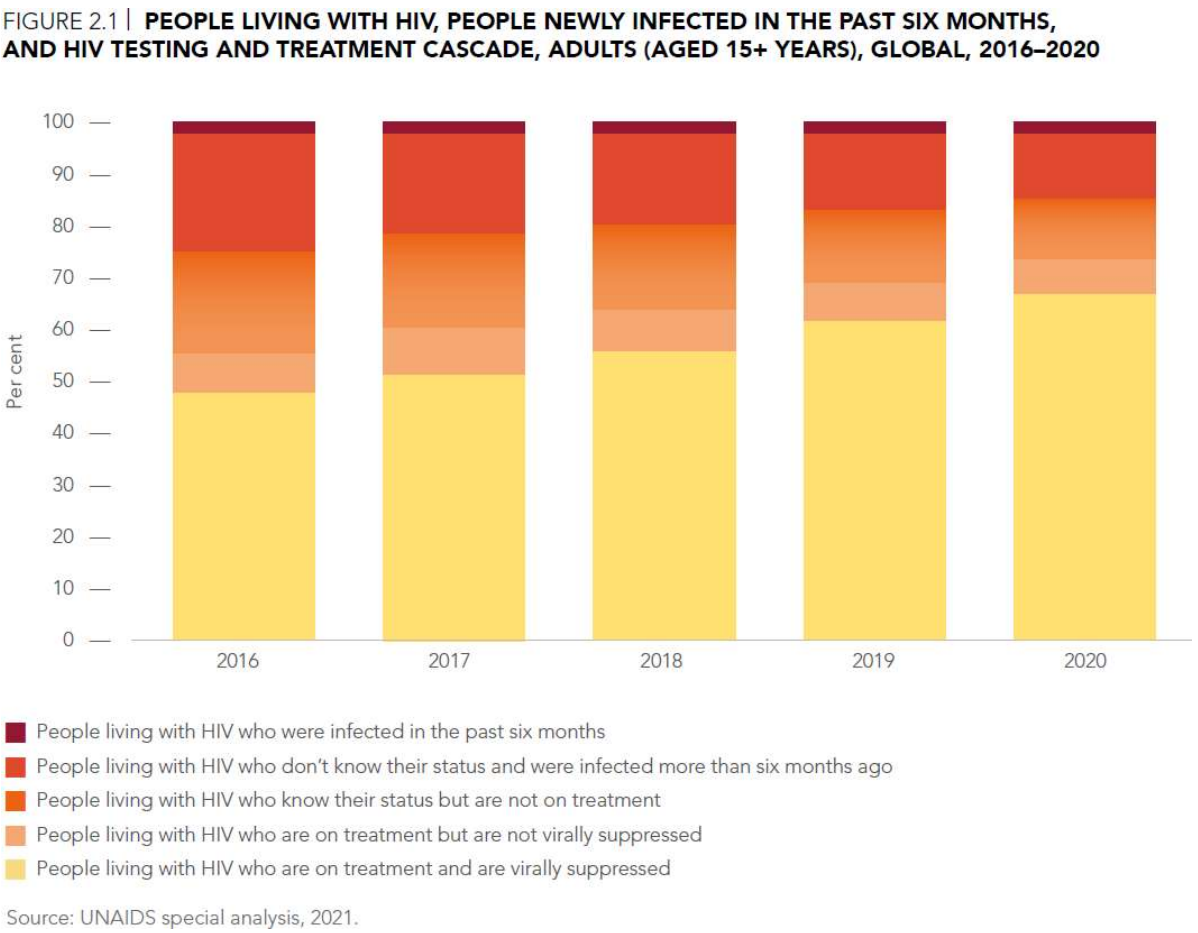

Figure 1: ART treatment cascade, source: UNAIDS data 2021 [6]

In 2014, UNAIDS announced its fast-track strategy to end the AIDS epidemic by 2030. The first objective was to reach fewer than 500,000 yearly new infections and a 90-90-90 target by 2020, referring to 90% of people living with HIV (PLWH) being diagnosed and knowing their HIV status, 90% of those diagnosed receiving ART and 90% of patients receiving ART achieving viral load goals, for a total 73% of all PLWH achieving viral suppression [7]. As of 2020, the first goal was not achieved with 680,000 new cases and an estimated 84% of PLWHaware of their status, 87% ART coverage and 90% viral suppression among ART patients [8]. UNAIDS defined an updated goal to reach a similar 95-95-95 target by 2025 [9].

In recent years, pre-exposure prophylaxis (PrEP) has emerged as a promising way to reduce HIV transmission among high-risk populations and an additional tool to prevent new infections. Treatment consists of a combination of ART drugs delivered through daily oral pills, on-demand treatment with oral pills before and after sex, and long-lasting delivery withinjections or vaginal ring. As of October 2021, 78 countries had experimented or authorized PrEP, with 1,544,777 PrEP treatment initiations globally [10].

Figure 2 shows the cumulative number of PrEP treatment initiations by country since its introduction.

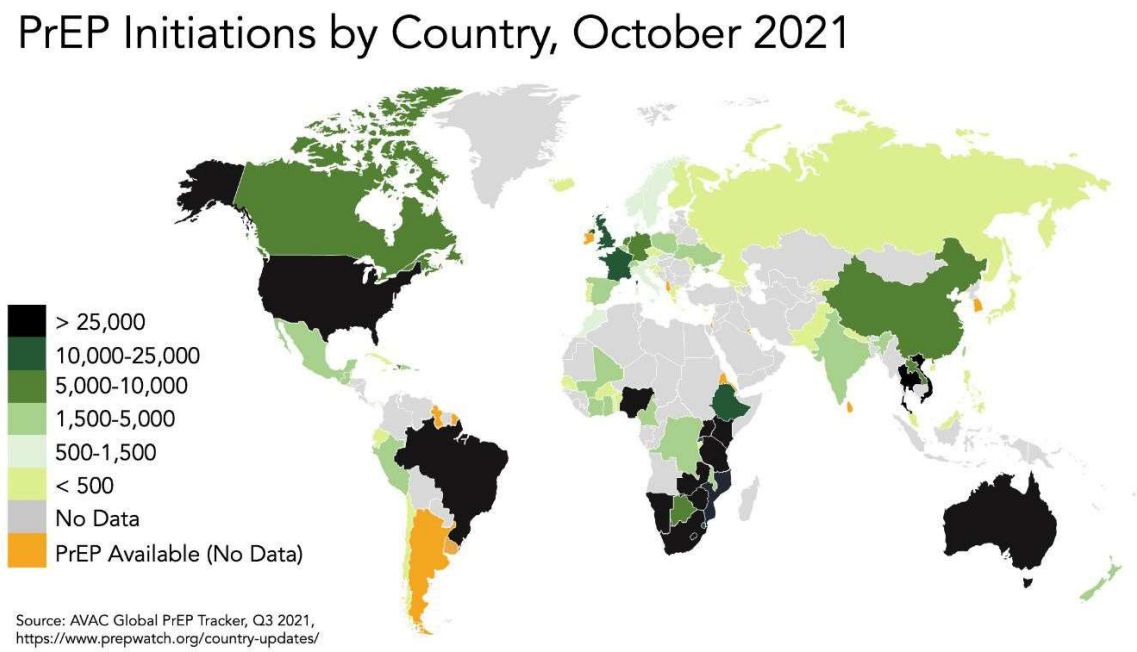

Figure 2: PrEP initiations by country, source: AVAC global PrEP tracker [10]

The effectiveness of PrEP has been proven among all populations, with a 51% reduction in risk of HIV infection [11]. Although the effectiveness varies according to adherence, with 70% risk reduction in high adherence patients but no significant reduction in low adherence groups, no difference was observed between the modes of transmission [11].

For example, projections in Japan estimate that a PrEP coverage of 25% to 75% of the 20% most at risk MSM could prevent 49.8% to 73.5% of new infections by 2050. If used in conjunction with attaining UNAIDS 90-90-90 target, over 90% of infections could be prevented by 2050 [12]. The estimated acceptance of PrEP among MSM globally was 57.8% between 2007 and 2016. It did not differ significantly between developed or developing countries, but younger, better educated and wealthier MSM were more likely to adhere to treatment but a low perceived susceptibility, fear of side-effects and high cost were the main obstacles [13].

Despite the known effectiveness of these strategies and continued efforts to curb the spread of the virus, in 2020 an estimated 37.7 million people were living with HIV, 1.5 million people were newly infected and 680,000 people died of related causes [8].

1.2. HIV in China

In 2020, there were 1.1 million PLWH in mainland China, for a prevalence of around 0.07% [14], with 148,586 new cases reported the previous year [15]. The objective to reach UNAIDS 90-90-90 target by 2020 was fixed by the government [15].
Most recent data from 2020 provided no estimate of the total number of PLWH, and thus no estimate of the proportion of diagnosed PLWH but only around 55% of key populations (sex workers, MSM and PWID) knew their HIV status, ART coverage had reached 89% or 980,000 patients, and 95.6% of viral suppression among patients receiving ART [14].
Since the first cases of HIV in 1985, the epidemic has been mostly concentrated among key populations, at first within PWID and now among sex workers and MSM. Geographical spread is uneven throughout the country, with southwestern provinces being more affected [16,17]. Chengdu is the capital city of the southwestern Sichuan province, with a population of over 16 million and a lot of migrant workers. It has historically been one of the centers of the HIV epidemic in China with a higher incidence than cities in the same province and than the national average. Although the incidence rate there is on a downwards trend, from 9.2/100PY in 2012-2013 to 3.09/100PY in 2018 [18], it is still far from eradicating the epidemic.

Until a decade ago, PWID were the main population of diagnosed HIV patients [19]. Since the 2000s strategies focusing on this group include behavioral interventions to reduce needle sharing, opening of needle syringe programs (NSPs), and methadone maintenance treatment. These strategies have been effective to control the epidemic, with the estimated prevalence among PWID nationwide declining from a peak of 10.4% in 2004 to 6.4% in 2011 [20].
The estimated prevalence of HIV among PWID in 2020 is still significant with 5.5%, and some barriers remain to elimination of HIV in this population. Only 55.2% of PWID were tested and aware of their HIV status in 2020, ART coverage is also still below the UNAIDS90-90-90 target with only 81.5% of diagnosed patients receiving treatment [14], and PWID remain a stigmatized and marginalized population at risk of HIV due to discrimination and criminalization.

In recent years the main mode of transmission of HIV in China has shifted to exposure through sexual behaviors. Men who have sex with men (MSM) are now a key population and efforts to fight the epidemic in the country have focused on this group. The estimated prevalence of MSM living with HIV increased from 1.3% in the early 2000s to 6.3% in recentyears[14,21–23]. The proportion of MSM among new HIV patients rose from 2.5% in 2006 to 25.8% in 2014 [24] and is still increasing with 33.4% of new patients in 2020 [19].

Prevention of sexual transmission revolves mainly around increasing condom use, testing, and providing ART. Sexual health education within traditional education institutions is lacking, with only 55.6% of college students having received reproductive health education [25]. Community-based organizations delivering health education and behavior intervention have gained importance, providing a trusted mediator with close connections to the MSM communities [16], with an objective to increase community-based service delivery to 30% [14]. NGOs are particularly involved in providing voluntary counselling and testing, and accounted for 28.9% of new diagnoses in 2015 [19].

A National free ART Program was established in 2003, with a fund to purchase drugs, a reduction of ART prices and free viral load tests for patients [19]. Following this, PrEP was approved and introduced in the country in 2020 but the number of patients is still relatively low, estimated at around 7,000 by October 2015 [26]. Under different scenarios with 25% to 75% of HIV-negative high-risk MSM coverage, PrEP could prevent 12.1% to 25.7% of new HIV infections in China between 2017 and 2037 [27]. If combined reaching the UNAIDS 90-90-90 target, this could prevent up to 75.3% of new infections over the same period [27]. However, willingness to pay for PrEP treatment was low with only 27.2% of MSM in Chengdu, China in 2020 willing to pay 85$ or more, which was the generic market rate [28].

With a high prevalence of HIV and common high-risk sexual behaviors [29], biomedical interventions are especially important in the efforts to control the epidemic in China. To be conducted efficiently, these interventions rely heavily on regular testing and easily accessible sexual health services (SHS) providing counseling, testing and treatment. Disruptions in the provision of these SHS and regular healthcare activities could pose additional challenges in HIV prevention. Key populations that are already stigmatized are even more prone to be disproportionately affected by those disruptions.

1.3. The COVID-19 pandemic's effects on HIV prevention activities

In December 2019, the first cases of what would become the COVID 19 pandemic were reported in the city of Wuhan, China. Since then and as of 19 December 2021, the total number of reported cases globally reached over 273 million, with over 5.3 million deaths attributed to the virus [30]. China adopted a zero covid policy aiming at eliminating the pandemic rather than mediating it. A strict lockdown with curfews, travel bans, mass gathering bans, public spaces closure and outing restrictions were implemented in Wuhan and most part of the Hubei province from 24 January 2020, with progressive easing of restrictions in the second half of March of the same year, ending in Wuhan itself on 8 April 2020. Almost every other province was placed under level 1 emergency response, the highest possible, healthcare resources allocation shifted towards the response to the pandemic, intense testing and contact tracing was performed, non-pharmaceutical interventions such as mask mandates, gathering restrictions or movement restrictions were put in place. These restrictions were progressively lifted after the first wave end in later March 2020 [31,32]. Since then, the number of cases remained low, consisting mainly of imported cases. A few subsequent outbreaks were rapidly controlled through contact tracing, mass testing, and localized lockdowns, most recently in Xi'an since 22 December 2021 after recording 1117 cases since the 9th of the same month [33].

Two different vaccines are available, Sinovac and CoronaVac, and as of the end of December2021, 83.6% of the Chinese population had received 2 injections of either vaccine [34].

However, China's COVID-prevention policy still focuses heavily on the prevention of outbreaks through lockdowns, mass screening and restrictions on social and economic activity. Such lockdowns can have significant disruptive effect on routine services, and may pose a risk to the continued function of HIV prevention services.

The impact of COVID 19 related policies on the accessibility of care and treatment of other conditions has been a concern, especially among the more vulnerable populations such as MSM, and disruption of services due to lockdowns and movement restrictions, or due to the collapse of medical care under the pressure of rapidly growing COVID pandemic, has been identified elsewhere. The USA saw 17.3% increased mortality in 2020, with 34% of excess life years lost being attributable to non-COVID 19 related causes. Minorities were especially affected, representing 70% of non-COVID 19 related excess deaths [35]. Excess mortality during the peak of the epidemic in Wuhan was not solely attributable to COVID 19. A 56% increase in the all-cause mortality rate between January and March 2020 was observed compared to predictions [36]. While

COVID 19 obviously increased the mortality by pneumonia, a significantly higher mortality from non-COVID 19 related pneumonia, as well as certain NCDs such as cardiovascular disease and diabetes was observed, highlighting the indirect danger of the impaired access to healthcare caused by policies implemented during the pandemic [36].

This disruption of non-COVID related services has extended to routine HIV prevention and treatment services. The Global Fund reported a drop of 41% of all populations HIV testing activity among 502 testing facilities across 32 African and Asian countries [37]. In several countries, MSM have experienced barriers to access HIV services as result of COVID 19- related policies. A large survey across 20 countries reported perceived restrictions to sexual health services access, with 38% of respondents reporting restrictions to in-person testing, 56% to PrEP and 55% to self-testing, and 20% HIV positive respondents reported inability toaccess their treatment provider, with 65% unable to renew their prescription remotely [38]. One survey in the UK reported that 30.2% of MSM respondents experienced difficulties in testing and treatment access during lockdown [39]. Another UK survey reported a shift from in-person visits to sexual health clinics, from 70.2% of visits in the 3 months before lockdown to 22.3% of visits in the 3 months after lockdown, to online self-sampling tests, from 17.1% to 64.3% in the same periods. Among respondents that reported multiple condomless anal sex partners or at least one new partner, only 36.5% did get tested, suggesting an unmet need for HIV screening. Among respondents that had not taken an HIV test since the lockdown began, 10% had sought but could not access testing [40]. In a USA survey, 25% of respondents reported reduced access to STI testing and treatment [41].

However, lockdowns and COVID risk reduction activities may have also led to a reduction in high-risk sexual behavior. When compared with an equivalent survey in 2017, MSM respondents in a UK survey in July 2020 were less likely to report new partners and condomless anal sex in the 3 months following the lockdown in March. 39.8% of respondents reported multiple condomless anal sex partners, or at least one new partner after the beginning of the lockdown [40]. In the USA, similar trends were reported, with 51.3% reporting a reduced number of sex partners [41]. These behaviors changes have sometimes been referred to as “sexual distancing” include a reduced number of partners as mentioned earlier, reduced intercourse frequencies, reduced intercourse with casual partners and reduced group sex, and have been reported in multiple other countries as well [42,43].

Similar responses were reported within China. Among the general population, the number of sexual partners was reduced by 17.6%, and frequency by 43.3% [44]. Among MSM, one survey in Hong Kong reported that 22.9% of respondents experienced moderate to high difficulties in accessing sexual health services, and 67.5% reported reduced connections with the LGBT community [45]. Although China's response to coronavirus has been very effective and has ensured that normal social and economic activity has been able to be maintained throughout 2020 and 2021, it is still possible that large-scale social changes occurring in early 2020 persisted and led to a long-term reduction in either access to testing and/or high-risk sexual behavior.

1.4. Objectives

The balance between the reduced risk from modified behaviors and the increased risk from the impaired access to sexual health services is uncertain. Given the potential of the COVID19 pandemic to indirectly affect other diseases through reduced access to healthcare and modified risk behaviors, it is crucial to evaluate its impact on the HIV epidemic which is a growing concern in China. MSM were already a key and vulnerable population that is morelikely to be disproportionately affected, however few studies have focused on this group.

The aim of this research is to quantify changes in the HIV epidemic factors among MSM inthe post COVID 19 era by:

- Quantifying the impact of the on yearly and quarterly test counts
- Evaluating the impact on time between tests for unique subjects
- Estimating changes in high-risk sexual behaviors

The results could potentially guide new policies aiming at reducing unmet needs and fillinggaps in sexual and reproductive health provision.

2. Methods

This was a retrospective cohort study of HIV testing and high-risk sexual behaviors.

2.1. Subject recruitment

Subjects were recruited in Chengdu, China, by an NGO providing free voluntary counselling and testing (VCT) to MSM. This NGO is the primary source of sex education and VCT, and plays an important role in HIV prevention activities in the city. As part of routine testing activity, NGO clients were interviewed before having their sample taken, and information wascollected through a structured questionnaire by NGO staff about their age, education, marital status, number of partners in the last 6 months, preferred way of meeting sexual partners, condom use during anal sex, group and commercial sex activity, other STI coinfections, HIV status of partner and substance use. Data was anonymous with a unique identifier generated from phone number allowing the linking to previous data for repeated test seekers. No active follow-up was conducted but this data was collected again on every subsequent visit.

Inclusion criteria were being 16 or older, having ever had at least one anal or oral sex experience with another man, and additionally for the survival analysis having at least two test observations on two separate dates. Data was collected between January 2012 and April 2021. For the analysis only entries from 2016 and onwards were included because of key behavioral risk variables that were not recorded before then.

2.2. Outcome variables and covariates

The main outcomes of interest were the time between two tests for a single patient, and the total count of tests in a given period. Secondary outcome were high-risk sexual behaviors, which were defined as having 6 or more sexual partners in the last 6 months, or not using acondom during anal sex every time in the last 6 months (subjects with no sexual partners in the last 6 months not included).

The study period was divided into pre- and post-pandemic periods. The post-pandemic period was defined as any time after 24 January 2020, when the first lockdown was enforced in the city of Wuhan and most provinces were place under emergency response. The NGO services were completely interrupted between 24 January and 24 March 2020. Since this study relies on voluntary testing, no active follow-up was available, survival analysis only included clients

that received multiple tests. The time period at risk for survival analysis was defined as the interval between the first and last test.

2.3. Ethical considerations

All subjects provided written consent for their data to be used in research. When attending the NGO, no patient was required to give their real name, and data was anonymized and provided to researchers from Sun Yat Sen University, Guangzhou, China and all relevant identifying data removed before being transferred to me. The study was approved by the Sun Yat Sen University institutional review board.

2.4. Statistical analysis

From this data, the incidence rate of testing was derived. Poisson regression was used to evaluate changes in test counts. A Cox proportional hazards regression model was used to estimate predictors of the time between two tests for a single patient and evaluate the impact of the pandemic on this interval. Logistic regression was used to evaluate changes in high riskof STI transmission sexual behaviors before and after the start of the pandemic. All covariates known to be associated with HIV risk and testing behavior that were consistently recorded were included in the model and backwards stepwise selection was used to select variables to include in the final models. This covariate list included education, marital status, number of partners in the last 6 months, preferred way of meeting sexual partners, condom use during anal sex, group and commercial sex activity, other STI coinfections, HIV status of partner and substance use.

All statistical analysis were performed using STATA.

3. Results

Over the 9 years and 4 months period, a total of 39,961 tests were recorded among 23,993 unique subjects. Of these, 3 observations were removed because of missing data about the time of testing, 335 observations were removed because of suspicions of ID sharing, whichwere identified as same-day visits by subjects with inconsistent age. 23,065 tests among 14,642 subjects were recorded since 2016.

3.1. Demographic and behavioral data

Table 1 summarizes subjects characteristics over the whole nine-year period. The characteristics of patients with multiple visits were included as individual observations in table 1 and 2. Mean age in this sample was 30 years old. The majority of subjects met online, either through chat and forums or mobile dating applications. Over 80% had between 1 and 5 sexual in the last 6 months before testing. About 1 in 3 clients had received college education, and 10% reported no anal sex in the last 6 months. Among those that did report anal sex, 54.57% reported using a condom every time.

Table 1: Subject characteristics

	Total (N = 39626)
Age	
Mean (SD)	30.33 (10.24)
Partner-seeking place	
Bar/park/other	2384 (7.9%)
QQ group/website/Wechat/Weibo	3567 (11.9%)
Bath house	3121 (10.4%)
Friend	2321 (7.7%)
Money boy club	329 (1.1%)
Mobile app	18362 (61.0%)
Marital status	
Married or cohabitation	7629 (19.5%)
Single	31500 (80.5%)
Number of partners in last 6 months	
0	1757 (5.9%)
1	9905 (33.2%)
2-5	15184 (50.9%)
6-9	1561 (5.2%)
10+	1403 (4.7%)
Education	
Middle school and below	4749 (12.1%)
High school or technical school	8540 (21.8%)
College	24637 (62.8%)
Master and above	1334 (3.4%)
Condom use	
Every time	14456 (49.1%)
Sometimes	1504 (5.1%)
Never	10529 (35.8%)
No anal sex	2951 (10.0%)
Substance use	
No	8708 (85.2%)
Yes	1518 (14.8%)

Group sex	
Never	4353 (80.6%)
Occasionally	945 (17.5%)
Often	100 (1.9%)
Sex worker	
No	9176 (90.5%)
Yes	962 (9.5%)
STD symptoms or diagnosis	
No	9834 (96.1%)
Unsure	24 (0.2%)
Yes	370 (3.6%)
Partner HIV status	
No HIV+ partners	3327 (38.0%)
Unsure	5155 (58.5%)
Yes, not on ART	60 (0.7%)
Yes, on ART	250 (2.8%)

Table 2 summarizes the same base characteristics but split between subject who were tested before and after the start of the pandemic. There was no difference in the age profile of subjects coming before or after 24 January. The preferred way to seek sexual partners differed between these time periods, with an increasing importance of mobile dating application, but this is likely due in part to time trends and an increased used of smartphones since 2012. The number of partners was also different after the pandemic, but little difference in the proportion of subjects reporting 6 or more partners. Condom use was higher after the pandemic, the proportion of subjects who reported anal sex in the last 6 months that used a condom every time reached 61.7% after the pandemic, compared to 53.8% before.

Table 2: characteristics before/after pandemic

	Before pandemic (N = 34519)	After pandemic (N = 5435)	p-value
Age			0.022
Mean (SD)	30.29 (10.24)	30.64 (10.31)	
Partner-seeking place			<0.001
Bar/park/other	1813 (7.3%)	570 (10.9%)	
QQ group/website/Wechat/Weibo	3373 (13.6%)	197 (3.8%)	
Bath house	2888 (11.6%)	230 (4.4%)	
Friend	1923 (7.7%)	396 (7.6%)	
Money boy club	301 (1.2%)	27 (0.5%)	
Mobile app	14547 (58.6%)	3819 (72.9%)	
Marital status			<0.001
Married or cohabitation	6775 (20.0%)	856 (16.4%)	
Single	27148 (80.0%)	4351 (83.6%)	
Number of partners in last 6 months			<0.001
0	1558 (6.2%)	198 (4.4%)	
1	7925 (31.4%)	1978 (43.7%)	
2-5	13315 (52.7%)	1874 (41.4%)	
6-9	1318 (5.2%)	242 (5.3%)	
10+	1163 (4.6%)	239 (5.3%)	
Education			<0.001
Middle school and below	4196 (12.3%)	555 (10.7%)	
High school or technical school	7673 (22.5%)	867 (16.6%)	
College	21227 (62.3%)	3409 (65.4%)	
Master and above	955 (2.8%)	378 (7.3%)	
Condom use			<0.001
Every time	11947 (47.6%)	2509 (57.9%)	
Sometimes	1287 (5.1%)	220 (5.1%)	
Never	9188 (36.6%)	1341 (30.9%)	
No anal sex	2685 (10.7%)	263 (6.1%)	

Substance use			<0.001
No	4143 (82.6%)	4566 (87.7%)	
Yes	875 (17.4%)	642 (12.3%)	
Group sex			0.004
Never	2428 (81.3%)	1927 (79.8%)	
Occasionally	520 (17.4%)	426 (17.6%)	
Often	39 (1.3%)	61 (2.5%)	
Sex worker			<0.001
No	4687 (94.6%)	4488 (86.6%)	
Yes	270 (5.4%)	693 (13.4%)	
STD symptoms diagnosis			0.019
No	4798 (95.6%)	5035 (96.7%)	
Unsure	15 (0.3%)	10 (0.2%)	
Yes	206 (4.1%)	164 (3.1%)	
Partner HIV infection			<0.001
No HIV+ partners	1291 (29.2%)	2036 (47.0%)	
Unsure	2965 (67.0%)	2160 (49.8%)	
Yes, and not on ART	35 (0.8%)	24 (0.6%)	
Yes, but on ART	137 (3.1%)	113 (2.6%)	

3.2. Testing behavior

The yearly number of tests in 2020 was lower than in previous years, with 3554 tests in 2020 compared to 4672 in 2019. It was the lowest since 2015, but this is expected due to the two-month interruption of services between January and March. Figure 3 shows the number of tests conducted in each year, by quarter. The first quarter in 2020 saw significantly less testing because of the suspension in testing activity, but it quickly recovered to levels comparable with previous years in the latter half of the year.

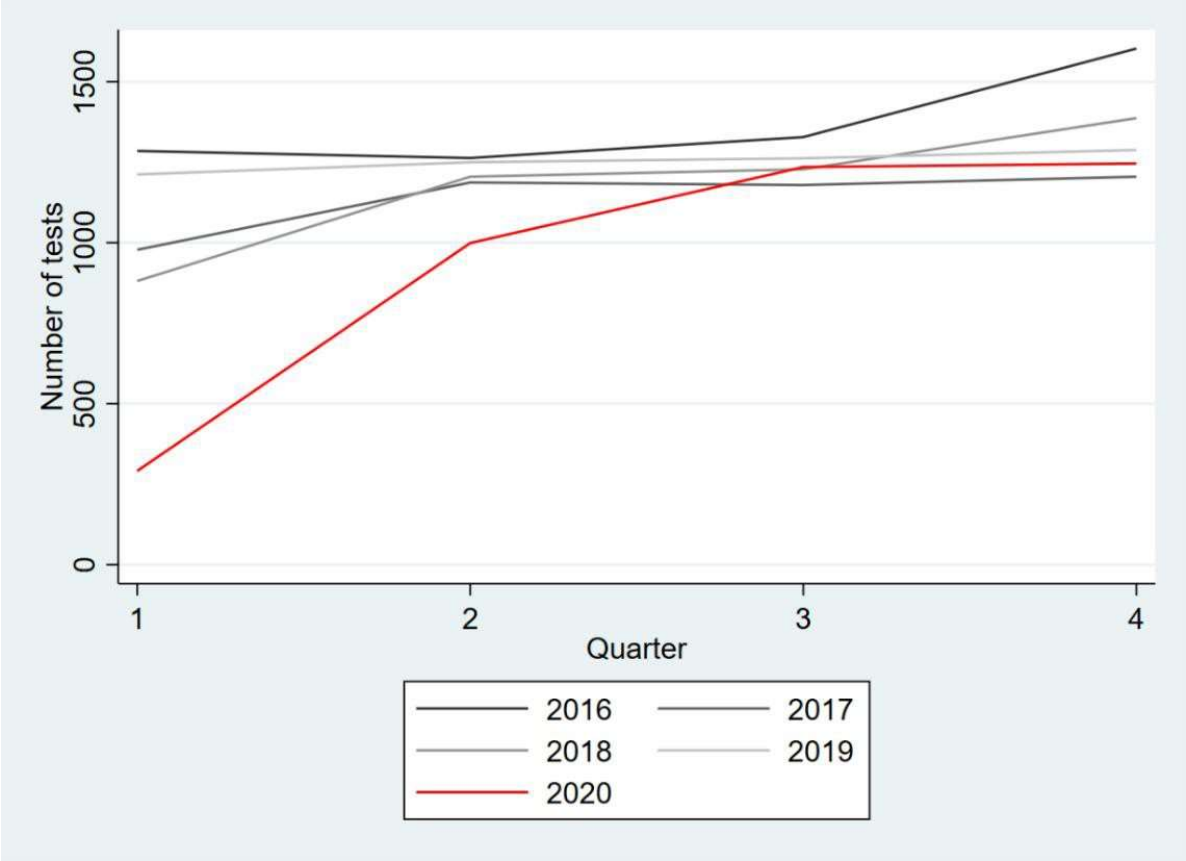

Figure 3: Tests per quarter by year

Table 3 shows the results of the Poisson regression of quarterly test count. Overall, the Poisson regression model found no significant effect of the pandemic on quarterly number oftests throughout 2020 (IRR= 0.79, p=0.2). This is not adjusted for covariates as it is a model of counts of quarterly data.

Table 3: Poisson regression model for quarterly number of tests

Variable	Incidence rate ratio	Standard error	z	P-value	95% confidence interval
Pandemic stage					
Before (reference)					
After	.79	.16	-1.18	0.2	[0.53 ; 1.17]
Year	1.03	.03	1.21	0.2	[0.98 ; 1.09]

4715 patients received at least two tests since 2016, for a combined 18454 tests that were included in survival analysis. Figure 4 shows the Kaplan Meier curves for the time until getting a subsequent test each year for subjects that received at least 2 tests between 2016 and 2021. 2020 seems to have a shorter interval between two tests than previous years.

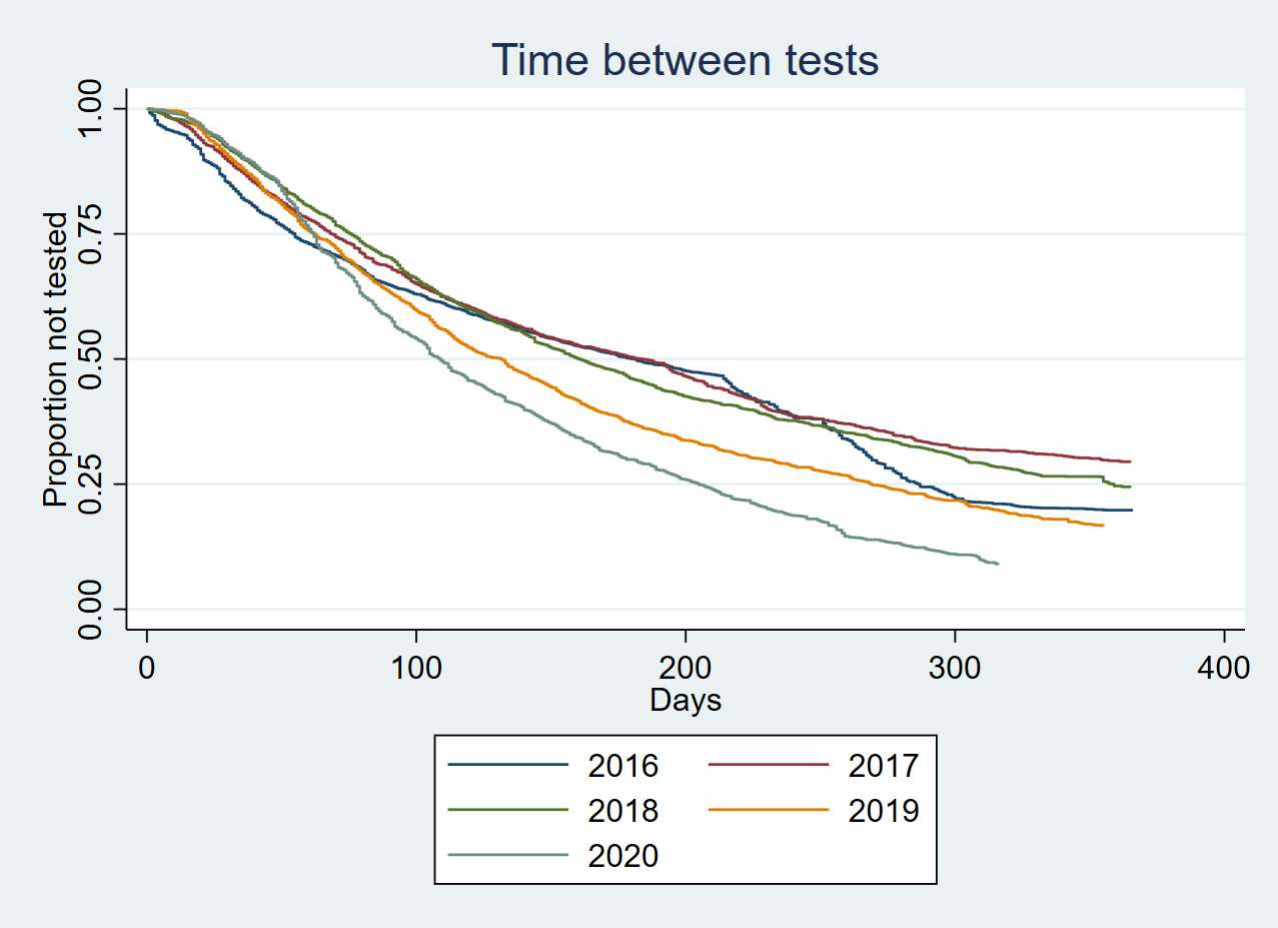

Figure 4: Time between tests by year

Table 4 shows the cox regression model for the time between two tests for subjects with repeated observations. The hazard ratio of receiving a test followed an increasing time trend throughout the years since 2016 (HR=1.07, p<0.001). The pandemic seems to have further increased the chances of testing and reduced the interval between two screenings by a further 20% (HR=1.20, p<0.001).

Table 4 : Cox regression model for time between tests

Variable	Hazard Ratio	Standard error	z	P-value	95% confidence interval
Pandemic stage					
Before (reference)					
After	1.20	.05	4.78	<0.001	[1.11 ; 1.29]
Year	1.07	.01	6.63	<0.001	[1.05 ; 1.09]
Partner-seeking place					
Bar / park / other (reference)					
QQ group / website / Wechat / Weibo	1.71	.09	10.15	<0.001	[1.54 ; 1.90]
Bath house	1.27	.07	4.45	<0.001	[1.14 ; 1.41]
Friend	1.14	.06	2.46	0.01	[1.03 ; 1.27]
Money boy club	1.21	.15	1.63	0.1	[0.96 ; 1.53]
Mobile app	1.16	.05	3.54	0.000	[1.07 ; 1.25]
Marital status					
Married or cohabiting (reference)					
Single	1.21	.03	6.63	<0.001	[1.14 ; 1.28]
Number of partners in last 6 months					
0 (reference)					
1	.66	.06	-4.69	<0.001	[0.55 ; 0.78]
2-5	.70	.06	-3.91	<0.001	[0.59 ; 0.84]
6-9	.76	.08	-2.80	0.005	[0.62 ; 0.92]
10+	.71	.07	-3.34	0.001	[0.59 ; 0.87]
Education					
Middle school or lower (reference)					
High school or technical school	1.06	.04	1.47	0.1	[0.98 ; 1.15]
College	1.10	.04	2.59	0.009	[1.02 ; 1.18]
Master and above	.90	.05	-1.85	0.06	[0.81 : 1.01]

Condom use during anal sex					
Always (reference)					
Sometimes	1.00	.02	-0.10	0.9	[0.95 ; 1.04]
Never	1.04	.06	0.77	0.4	[0.94 ; 1.16]
No anal sex	.89	.04	-2.59	0.01	[0.81 ;0.97]

The way subjects meet sexual partners is also associated with the time between tests. Subjects meeting on online chats, in bath houses, through friends or mobile dating applications all have a higher rate of tests compared to subjects meeting in bars, parks or other places. Being single was also associated with a shorter interval between tests. A higher number of partners was associated with reduced chances of testing compared to not having any partner in the last 6 months. College was the only education level with a significant association with testing. Condom use had no impact either, but subjects who did not have anal sex in the last 6 months were less likely to get tested.

3.3. Risk behaviors

Table 5 shows the results of the logistic regression of the odds of having a high number of partners in the last 6 months. After adjusting for covariates, the pandemic had no significant effect on the proportion of people having a high number of partners (OR=1.14, p=0.08).

Table 5: Logistic regression of high number of partners

Variable	Odds ratio	Standard error	z	P-value	95% confidence interval
Pandemic status					
Before (reference)					
After	1.14	.08	1.76	0.08	[0.99 ; 1.31]
Partner-seeking place					
Bar / park / other (reference)					
QQ group / website / Wechat / Weibo	.27	.084	-4.21	<0.001	[0.14 ; 0.49]
Bath house	1.21	.16	1.49	0.1	[0.94 ; 1.57]
Friend	.29	.07	-5.40	<0.001	[0.19 ; 0.46]
Money boy club	1.00	.39	-0.00	0.99	[0.46 ; 2.15]
Mobile app	.63	.07	-4.15	<0.001	[0.51 ; 0.78]

Education					
Middle school or lower (reference)					
High school or technical school	.89	.10	-1.06	0.3	[0.71 ; 1.11]
College	.67	.07	-3.79	<0.001	[0.55 ; 0.82]
Master and above	.77	.14	-1.46	0.1	[0.54 ; 1.09]
Sex worker					
No (reference)					
Yes	2.03	.23	6.21	<0.001	[1.62 ; 2.54]
Marital status					
Married or cohabitation (reference)					
Single	.64	.05	-5.29	<0.001	[0.54 ; 0.75]
Partner HIV infection					
No (reference)					
Unsure	4.38	.46	14.22	<0.001	[3.57 ; 5.37]
Yes, and not on ART	4.04	1.72	3.28	0.001	[1.76 ; 9.30]
Yes, but on ART	2.93	.69	4.56	<0.001	[1.84 ; 4.65]
Other STD coinfection					
No (reference)					
Unsure	.83	.63	-0.24	0.8	[0.19 ; 3.66]
Yes	1.65	.27	3.12	0.002	[1.20 ; 2.27]

Predictors associated with a lower number of partners were college education compared to middle school or lower education (OR=0.67, p<0.001), and being single (OR=0.64, p<0.001). On the other hand, partner HIV infection, both treated (OR=2.93 p<0.001) and untreated (OR=4.04 p=0.001) as well as uncertainty about partner HIV status (OR=4.38 p<0.001) were associated with a higher number of partners compared to subjects with non-infected partners. Having another STD coinfection was also associated with having 6 or more partners in the last 6 months (OR=1.65, p=0.002). Sex workers also had a significant higher number of partner (OR=2.03, p<0.001)

Table 6 shows the logistic regression between always using a condom during anal sex and main covariates. The pandemic did not have a significant effect on the proportion of subjects using a condom every time (OR=1.06, p=0.2).

Table 6: Logistic regression of condom use

Variable	Odds Ratio	Standard error	z	P-value	95% confidence interval
Pandemic status					
Before (reference)					
After	1.06	.05	1.25	0.2	[0.97 ; 1.17]
Partner-seeking place					
Bar/park/other (reference)					
QQ group / website / Wechat / Weibo	1.18	.17	1.14	0.3	[0.89 ; 1.57]
Bath house	1.61	.17	4.43	<0.001	[1.30 ; 1.99]
Friend	1.30	.15	2.27	0.02	[1.04 ; 1.63]
Money boy club	4.56	1.86	3.72	<0.001	[2.05 ; 10.16]
Mobile app	1.38	.11	4.02	<0.001	[1.18 ; 1.61]
Number of partners in last 6 months					
1 (reference)					
2-5	.94	.05	-1.21	0.2	[0.84 ;1.04]
6-9	.85	.09	-1.61	0.1	[0.70 ;1.04]
10+	.79	.08	-2.16	0.03	[0.64 ; 0.98]
Education					
Middle school or lower (reference)					
High school or technical school	1.27	.11	2.69	0.007	[1.07 ; 1.50]
College	1.82	.14	7.62	<0.001	[1.56 ; 2.13]
Master and above	1.71	.20	4.64	<0.001	[1.36 ; 2.15]
Sex worker					
No (reference)					
Yes	1.12	.09	1.41	0.2	[0.96 ; 1.32]
Marital status					
Married or cohabitation (reference)					
Single	.98	.06	-0.38	0.7	[0.86 ; 1.11]

Partner HIV infection					
No (reference)					
Unsure	.69	.04	-6.84	<0.001	[0.62 ; 0.77]
Yes, and not on ART	0.36	0.11	-3.49	<0.001	[0.21 ; 0.64]
Yes, but on ART	.95	.14	-0.33	0.7	[0.71 ; 1.27]
Other STD coinfection					
No (reference)					
Unsure	.66	.31	-0.89	0.4	[0.27 ; 1.64]
Yes	.55	.07	-4.80	<0.001	[0.43 ; 0.70]

Education is a significant factor, with people educated at high school (OR=1.27, p=0.007), college (OR=1.82, p<0.001) and master level or above (OR=1.71, p<0.001) being more likely to always use condoms compared to subjects with a middle school or lower education. Having an HIV positive partner not on ART (OR=0.36, p<0.001) or being unsure about partner HIV status (OR=0.69, p<0.001) was associated with a less frequent use of condoms compared to having an HIV negative partner. On the other hand, having a HIV positive partner but on ART was not linked with a different condom usage (OR=0.95, p=0.7). Respondents with another STI were more likely to not be using a condom every time (OR=0.55, p<0.001).

4. Discussion

This study evaluated the impact of COVID 19 pandemic and the associated policies on HIV prevention-related activities, specifically HIV testing and high-risk behaviors. Almost 40,000 tests among almost 24,000 subjects were included in the final analysis. Despite an early drop in test counts at the beginning of the pandemic, no significant long-term effect of the pandemic on quarterly testing was observed. For subjects who received multiple tests, the interval between tests has been decreasing throughout the years, and the pandemic amplified this phenomenon. Regarding high-risk behaviors (not always using a condom during anal sex, over 6 partners in the last 6 months) differences were observed before and after the pandemic but after adjusting for confounders, the pandemic did not induce any significant modification.

Limitations of this study are the fact that it is based on voluntary testing by clients and did not have follow-up to monitor changes for all patients that were ever included. Instead, only information about patients who actually received a test after March 2020 is available to evaluate the studied behavior changes. The monocentric design is another limitation of this study, the epidemiology of HIV in Chengdu, which is one of the key regions for the HIV epidemic in the country, might not be directly applicable to the rest of China.

Other studies have found that social distancing and quarantines have impacted the sexual behaviors of MSM in western Europe, with a reduced number of partners and modifications of behaviors and practices [39,46,47]. Surveys in the UK showed that MSM still experienced difficulties in accessing HIV services in the months after lockdown was lifted [40]. One study in Australia also reported a decrease in the number of sexual partners during a second lockdown compared to the period between the first and second lockdown, suggesting that additional lockdowns have a similar effect on sexual behavior. Access to HIV services and pre-exposure prophylaxis treatment was also reduced during the second lockdown, despite usual operating hours, among 136 MSM taking daily PrEP during the period between first and second lockdown in Australia, 16% stopped all form of PrEP during the second lockdown, and 2% switched to on-demand PrEP [48].

Overall, relatively few studies have focused on SHS disruptions and their effect on HIV testing and prevention among MSM. Of those few studies, most consist of surveys about theperceived barriers but did not evaluate actual changes in testing or treatment numbers.

Another strength of our study is the longer-term evaluation compared to previous studies that focused on periods during or shortly after lockdowns.

Given this absence of available data on the effect of the pandemic on testing and risk behavior, some researchers have used mathematical models to estimate the potential effect of pandemic responses on testing activity. Models based on early observations projected a very modest but overall decrease in new HIV infections by 1.6% and a slight 0.6% increased mortality over 5 years, with the effect of the modified sexual behaviors mitigating the reducedaccess to testing, on the hypothesis of a 3-month duration for the disruption of services and behavior changes [49]. Our findings support this initial assumption of a short few months of disruption with a return to normal, however this might not be applicable to other countries. These projections were based on a continuous 3 months disruption but models with repeated disruptions might be more representative of the real consequences in most western countries.

Chinese management of the COVID 19 pandemic has brought the disease mostly under control with occasional localized imported cluster outbreaks suppressed by quick responses. As a result, access to HIV testing and counseling has resumed and caught up with previous years in the city of Chengdu, one of the most important cities in the HIV epidemic in the country. These observations might not be applicable to other countries that did not manage to contain the pandemic as well and where community transmission, restrictions and the strain on the healthcare system is more important.

No report on countrywide progress towards controlling HIV was published in 2020, but we could assume that the UNAIDS 90-90-90 target has not been met based on 2019 data. Now that disruptions have been overcame in most of the country, the Chinese policies should focus particularly on identifying and diagnosing PLWH, which was the lagging component inmeeting their 2020 goals. Continued activity to prevent community-wide COVID transmission should also be maintained, as they have been able to ensure that other health services continue uninterrupted, and maintain other public health related activities that have been severely disrupted in countries that did not pursue a zero-covid strategy. Preventing outbreaks of novel coronavirus, or focusing on eliminating existing outbreaks, is the only wayto ensure continued progress towards UNAIDS goals, and the ultimate objective of eliminating HIV, both in China and globally. Determined action against coronavirus is an essential precondition to ensuring a world free of HIV, and the ultimate goal of health for all.

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