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Original Article

# Impact of coronavirus disease 2019 on the HIV testing and health care delivery at a university hospital in Taiwan, 2020–2021



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## KEYWORDS

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 intervention;  
 Voluntary counseling  
 and testing;  
 Care cascade;  
 Antiretroviral therapy

**Abstract** *Background:* To contain the coronavirus disease 2019 (Covid-19) pandemic, non-pharmacologic interventions, including lockdown and social distancing, may have adverse impact on access to HIV testing and care. This study investigated the impact of Covid-19 on HIV testing and care at a major hospital in Taiwan in 2020–2021.

*Methods:* The numbers of clients seeking anonymous HIV voluntary counseling and testing were compared 2 years before (2018–2019) and 2 years after Covid-19 outbreak (2020–2021). People living with HIV (PLWH) who sought care at the hospital during 2018–2021 were included to examine the status of HIV care delivery and disposition.

*Results:* The annual number of HIV screening tests performed had significantly decreased from 2507 to 2794 in 2018 and 2019, respectively, to 2161 and 1737 in 2020 and 2021, respectively. The rate of discontinuation of HIV care among PLWH was 3.7% in 2019, which remained unchanged in 2020 (3.7%) and 2021 (3.8%). The respective percentage of annual plasma HIV RNA testing <2 times increased from 8.4% to 7.8% in 2018 and 2019 to 7.0% and 10.7% in

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2020 and 2021, so was that of annual syphilis testing <2 times (10.1% and 8.8%–7.9% and 12.0%). The rates of plasma HIV RNA <200 copies/ml ranged from 97.0% to 98.1% in 2018–2021. *Conclusions:* During the Covid-19 pandemic, access to HIV counseling and testing was significantly limited. While the number of HIV-related testing decreased, the impact of Covid-19 on the continuity of antiretroviral therapy and viral suppression among PLWH appeared to be minimal in Taiwan.

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## Introduction

Coronavirus disease 2019 (Covid-19) has spread rapidly around the world since the first report from Wuhan in China in December 2019.<sup>1</sup> Covid-19 may have short-term and long-term detrimental health impact on the immune system, respiratory system, cardiovascular system, neurological system and mental health.<sup>2</sup> During this Covid-19 pandemic, the World Health Organization (WHO) estimates that approximately 37.7 million people living with HIV (PLWH) worldwide are at risk for infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).<sup>3</sup> To contain the pandemic, wearing personal protective equipment, travel restrictions, social distancing, and lockdown have been implemented, which could potentially have adverse impact on HIV testing and care delivery, including initiation of antiretroviral therapy (ART) and retention in HIV care.<sup>4–8</sup> Because of non-pharmaceutical interventions (NPIs) and concerns about acquisition of SARS-CoV-2, people at risk may become hesitant to undergo timely testing for HIV and more likely to delay in seeking care when HIV infection is confirmed, which could potentially lead to delayed initiation of antimicrobial prophylaxis and ART and increased disease severity and complications.<sup>9,10</sup> In a retrospective cohort study conducted in four continents, the number of HIV tests performed was reduced by 35.4% in 2020 as compared with that in 2019.<sup>6</sup> In hospital-based studies, the new patient encounters decreased by 23.5%–35.0% during the lockdown in the USA and the Netherlands.<sup>5,7</sup> Moreover, ART initiation was shown to decrease from a median of 571 per week before lockdown to 375 per week after lockdown in 65 South African primary care clinics.<sup>4</sup>

While the extent to which the adverse impact of the pandemic may have depends on the severity of the pandemic, preparedness of public and private sectors, and efficiency of strategies to contain the pandemic, the patients with chronic health conditions, including HIV, will be most severely hit in the long-term.<sup>10</sup> A modelling study predicted that modest Covid-19-related disruptions to HIV testing, initiation pre-exposure prophylaxis (PrEP) and PrEP adherence, condom use, ART initiation and viral suppression could lead to increases in new HIV infections and HIV-related deaths.<sup>11</sup> To minimize the adverse impact on the provision of HIV prevention to key populations and the delivery of appropriate care to PLWH during the pandemic, prevention and treatment programs need to be flexible and innovative and to partner with non-governmental organizations.<sup>12–14</sup>

In this study, we aimed to investigate the impact of Covid-19 pandemic on the HIV testing and care delivery at a university hospital in Taiwan during the outbreak in 2020–2021.

## Methods

### Study setting

On 21 January, 2020, the first person infected with SARS-CoV-2 was diagnosed in the Taiwan.<sup>15</sup> As of 31 December, 2021, the total case number of SARS-CoV-2 infection reported to the National Health Command Center (NHCC) was 14,603 cases in a country with a population of around 24 million people. By the end of May 2022, 2,032,983 cases of SARS-CoV-2 infection were diagnosed with 2255 deaths.<sup>16</sup> To contain the epidemic, border control, mandatory quarantine for returned travelers and individuals infected with SARS-CoV-2, vaccination, and several NPIs were implemented; these NPIs included wearing face mask and social distancing, in addition to promoting awareness of personal hygiene and sanitation. Selective restrictions on entry into the hospital were implemented with check-up of body temperature and review of sick contacts, vaccination, and recent travel.<sup>17</sup>

Vaccination programs against SARS-CoV-2 started on March 22, 2021, which first began to cover infectious disease prevention and control personnel at the central and local governments and front-line workers at high risk of exposure. Adult people with chronic illnesses, including PLWH, were prioritized in vaccination programs that was initiated on 8 July, 2021.<sup>18</sup> A retrospective study in Taiwan suggested that COVID-19 vaccination was clinically effective in preventing SARS-CoV-2 infection among PLWH.<sup>19</sup> As of 31 May, 2022, it was estimated that 88.8% of the total population had received the first dose, 81.9% the second, and 65.7% additional doses of a Covid-19 vaccine in Taiwan.<sup>20</sup>

### HIV testing, prevention and care delivery

HIV testing are mandatory for individuals entering military service, prisons and correctional facilities. Opt-out HIV testing program has been implemented for women receiving antenatal care since 2005. Free-of-charge HIV screening testing is also provided at the designated hospitals and clinics. The program of home HIV testing was implemented in 2020, in which the free-of-charge testing kits are available at vending machines as well as

convenience stores around Taiwan after registration on-line with the Taiwan Centers for Disease Control (CDC).

According to the national HIV treatment guidelines in Taiwan, PLWH have free-of-charge access to HIV care, including ART and monitoring of CD4 and plasma HIV RNA load, at designated hospitals around Taiwan. Antiretroviral-naïve PLWH are counseled to start ART regardless of CD4 count since 2015.<sup>21</sup> Several single-tablet regimens (STRs), including regimens containing second-generation integrase inhibitors, were introduced into clinical use in 2016. Initiation of ART within 7 days of HIV diagnosis was recommended in 2018; after introduction of immunochromatographic testing to facilitate rapid confirmation of HIV diagnosis in 2020, same-day ART initiation was recommended in 2021.<sup>22</sup> Once ART is initiated, follow-up of virologic response is conducted at 1 month of ART, and subsequently every 3 months during the first year and every 6 months once PLWH have achieved viral suppression on stable ART.<sup>23</sup> The annual number of newly diagnosed HIV infection reported to the Taiwan CDC reported has been on the decline for four consecutive years since 2018.<sup>24</sup>

During the epidemic, HIV care provided at designated hospitals around Taiwan was not interrupted, including PrEP and post-exposure prophylaxis (PEP), HIV screening, ART, and management of opportunistic illnesses. PLWH who stayed abroad or were quarantined could have their ART refilled at the designated hospitals and delivered by mail with the assistance of their families, friends, or volunteer workers at non-governmental organizations (NGOs). PLWH can refill ART by making on-line appointments with designated hospitals or pharmacies.

### Study population and design

In this retrospective cohort study, we included PLWH receiving care at the National Taiwan University Hospital (NTUH), the major designated hospital providing inpatient and outpatient care, in 2018–2021. To examine the impact of Covid-19 on HIV testing, the numbers of clients seeking anonymous HIV voluntary counseling and testing (VCT) in the same periods in 2018–2021 were compared. To evaluate the linkage to care for those testing HIV-positive, the interval between HIV diagnosis and first visit at HIV clinics as well as that between confirmed HIV diagnosis and ART initiation were recorded.

We systematically extracted and validated all laboratory and clinical data from the electronic medical records. Patients were included if they had at least one medical visit at NTUH between January 1, 2018, and December 31, 2021. Discontinuation of HIV care was defined as individuals having less than 1 medical visit within 6 months. Follow-up was censored at death or at the end of study on 31 December, 2021. Outcomes assessed included attendance at the HIV clinics by PLWH themselves, family, friends or non-governmental organizations; performance of HIV care-related testing such as rapid plasma reagin (RPR) for syphilis, hepatitis C virus (HCV) antibodies or HCV RNA, and plasma HIV RNA; and plasma HIV RNA <200 copies/ml or <50 copies/ml. These variables were chosen to assess the HIV care continuum that encompasses a series of HIV care-

related steps from HIV diagnosis to linkage to care, retention in care, and to viral suppression.<sup>25</sup>

### Laboratory investigations

Plasma HIV RNA load was quantified using the Cobas HIV-1/HIV-2 Qualitative nucleic acid test (Cobas 6800 System, Roche Diagnostics Corporation, IN, USA) with the lowest detection limit of 33 IU/mL (1 copy = 1.67 IU). CD4 counts were determined using FACFlow (BD FACS Calibur, Becton Dickinson, CA, USA). ASI's nontreponemal RPR test screens (CPT Code 86,593, Springville, UT, USA) was used for the diagnosis of syphilis. Anti-HCV antibodies were determined with the use of a fourth-generation enzyme immunoassay (Dia.Pro Diagnostic Bioprobes S.r.l. Italy). The detection of HCV RNA was performed using Roche Cobas® 6800 system (AmpliPrep HCV Test, v2.0, Roche, USA), with a detection limit of 15 IU/mL. In June 2019, pooled-plasma HCV RNA testing program was implemented to facilitate early diagnosis of HCV viremia and linkage to direct-acting antiviral (DAA) treatments among PLWH at risk for HCV acquisition, such as PLWH newly diagnosed with sexually transmitted infections (STIs), elevated aminotransferases, and recent clearance of HCV with DAAs or spontaneously; those included in the program underwent HCV RNA testing every 12 weeks for 48 weeks.<sup>26</sup>

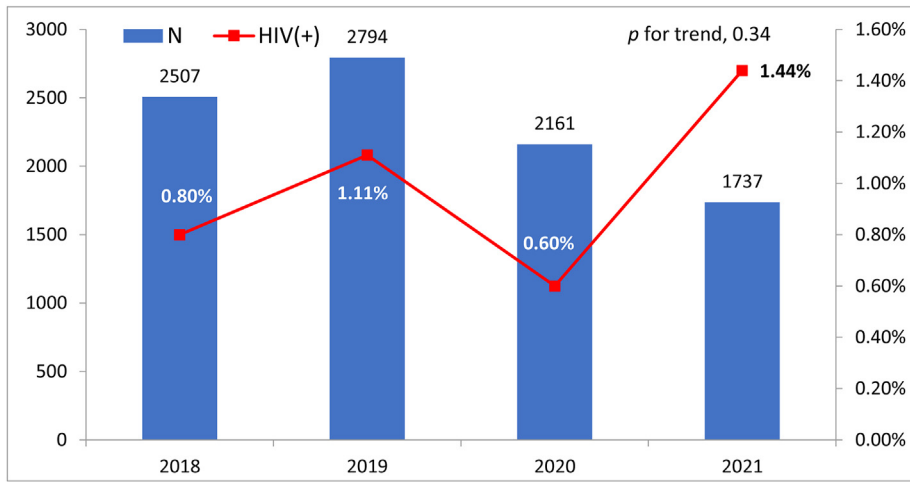
### Statistical analysis

We used descriptive statistics to summarize the VCT testing for HIV and clinical data among PLWH before and after Covid-19 outbreak. The variables included in this analysis were the number of HIV tests performed and the percentage of clients testing HIV-positive at the VCT service; and the coverage of Covid-19 vaccination and the number of attendance at the HIV clinics, and plasma HIV RNA and RPR tests performed. Differences in the numbers of HIV tests and percentages of clients testing HIV-positive for the four consecutive study years were compared by *p* for trend. SAS (version 9.4) was used for all analyses.

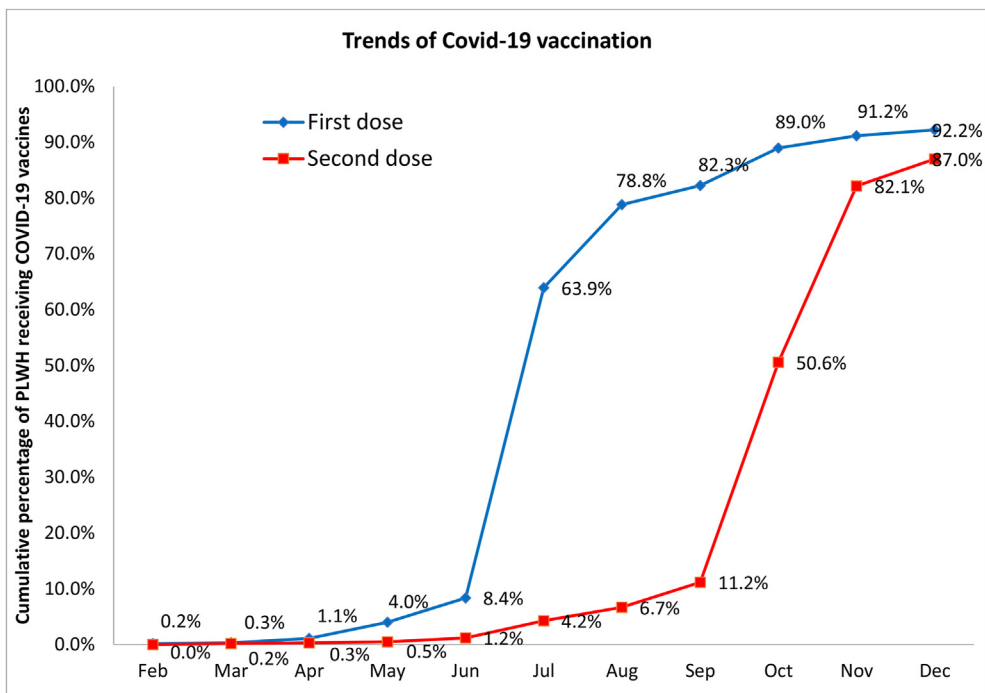
## Results

### Trends of HIV testing performed at VCT service

The number of HIV tests performed at VCT service had significantly decreased, from 2507 to 2794 in 2018 and 2019, respectively, to 2161 and 1737 in 2020 and 2021, respectively, a 37.8% decrease from 2019 to 2021 (Fig. 1). However, the percentages of clients testing HIV-positive remained relatively stable during the 4-year study period, from 0.8% (*n* = 20) and 1.1% (31) in 2018 and 2019, respectively, to 0.6% (13) and 1.4% (25) in 2020 and 2021, respectively (*P* for trend, 0.34) (Fig. 1). The rate of linkage to care for the clients testing HIV-positive at VCT service was 85.0% (17/20), 93.5% (29/31), 100% (13/13), and 96.0% (24/25) in 2018, 2019, 2020, and 2021, respectively.



**Figure 1.** The numbers of for HIV tests performed at voluntary counseling and testing service (bar) and the rates of HIV seropositivity (curve) in 2018–2021.



**Figure 2.** Cumulative coverage of COVID-19 vaccination among people living with HIV (PLWH) seeking care at the National Taiwan University Hospital in February to December 2021.

### SARS-CoV-2 vaccine coverage

Types of vaccines available in Taiwan included ChAdOx1 nCoV-19 (AZD1222), BNT162b2 (Pfizer-BioNTech), mRNA-1273 (Moderna), and MVC-COV1901 (Medigen); PLWH traveling to China might receive CoronaVac (Sinovac) or BBIBP-CorV (Sinopharm) vaccines. From February 2 2021 to December 31, 2021, 87.0% (2974/3420) PLWH had received 2 vaccine doses (Fig. 2); the types of vaccines administered were 96.5% (2870/2974) homologous vaccines (AZD1222-AZD1222, n = 1736; BioNTech–BioNTech, n = 384; Moderna–Moderna, n = 610; Medgen–Medgen, n = 118; Sinovac–Sinovac, n = 14, Sinopharm–Sinopharm, n = 8); and

3.5% (104/2974) heterologous vaccines (AZD1222-BioNTech, n = 31; AZD1222-Moderna, n = 72; AZD1222-Medgen, n = 1).

### HIV care delivery to people who were newly diagnosed with HIV infection

The numbers and clinical characteristics of PLWH who sought HIV care during the four study years are shown in Table 1. The majority of the included PLWH were male (ranging from 95.9% to 96.2%) and men who have sex with men (from 90.9% to 91.9%). The annual case number of people who were newly diagnosed with HIV infection and

**Table 1** Clinical characteristics of people living with HIV who sought care at the National Taiwan University Hospital and blood testing related to HIV care performed between 2018 and 2021.

Total patient number, n =	2018	2019	2020	2021
	3116	3177	3178	3188
Age, mean (SD), years	41.1 (11.0)	41.8 (10.9)	42.6 (10.9)	43.4 (10.9)
Male sex, n (%)	2988 (95.9)	3051 (96.0)	3055 (96.1)	3066 (96.2)
Risk group for HIV transmission, n (%)				
MSM	2831 (90.9)	2895 (91.1)	2904 (91.4)	2929 (91.9)
Heterosexuals	249 (7.9)	246 (7.7)	241 (7.6)	230 (7.2)
IDUs	29 (0.9)	29 (0.9)	26 (0.8)	22 (0.9)
Others	7 (0.2)	7 (0.2)	7 (0.2)	7 (0.2)
Plasma HIV RNA, mean (SD), log <sub>10</sub> copies/ml	1.4 (0.5)	1.4 (0.5)	1.4 (0.4)	1.4 (0.4)
People newly diagnosed with HIV infection, n (%)	85 (2.7)	86 (2.7)	55 (1.7)	53 (1.7)
CD4 count at diagnosis, median (IQR), cells/ $\mu$ L	278 (156–413)	259 (89–413)	222 (72–367)	257 (71–360)
CD4 <200 cells/ $\mu$ L, n (%)	30 (35.3)	31 (36.0)	25 (45.5)	19 (35.8)
Plasma HIV RNA, median (IQR), log <sub>10</sub> copies/ml	4.9 (4.6–5.4)	5.0 (4.4–5.4)	5.1 (4.6–5.8)	5.2 (4.3–5.9)
Plasma HIV RNA >5 log <sub>10</sub> copies/ml, n (%)	40 (47.1)	42 (48.8)	31 (56.4)	27 (52.9)
Interval between confirmed HIV diagnosis and ART initiation, median (IQR), days	5 (2–7)	5 (3–7)	5 (2–7)	0 (0–1)
Total number of RPR tests performed	7816	7895	7545	7207
No. of annual RPR tests for each PLWH, median (IQR)	2 (2–3)	2 (2–3)	2 (2–3)	2 (2–3)
PLWH without any RPR test, n (%)	63 (2.0)	60 (1.9)	75 (2.4)	112 (3.5)
PLWH with annual RPR tests <2, n (%)	316 (10.1)	278 (8.8)	252 (7.9)	384 (12.0)
PLWH with annual RPR tests $\geq$ 2, n (%)	2737 (86.4)	2839 (89.4)	2851 (89.7)	2692 (84.4)
Total number of anti-HCV antibodies or HCV RNA tests performed	3216	4276	4783	4823
No. annual anti-HCV antibody or HCV RNA tests for each PLWH, median (IQR)	1 (0–1)	1 (1–2)	1 (1–2)	1 (1–2)
PLWH without any anti-HCV antibody or HCV RNA test, n (%)	1039 (33.3)	312 (9.8)	360 (11.3)	249 (7.8)
Total no. plasma HIV RNA tests performed	7927	7839	7509	7205
No. annual HIV viral load test for each PLWH, median (IQR)	2 (2–3)	2 (2–3)	2 (2–3)	2 (2–3)
PLWH without any viral load test, n (%)	36 (1.2)	38 (1.2)	57 (1.8)	94 (2.9)
PLWH with annual viral load tests <2, n (%)	262 (8.4)	247 (7.8)	223 (7.0)	342 (10.7)
PLWH with annual viral load test $\geq$ 2, n (%)	2818 (90.0)	2892 (91.0)	2898 (91.2)	2752 (86.3)
Plasma HIV RNA $\leq$ 200 copies/ml in on-treatment population, % (n/N) <sup>a</sup>	97.0% (2988/3080)	97.3% (3037/3122)	98.1% (3013/3070)	97.7% (3023/3093)
PVL <200 copies/ml in modified intention-to-treat population, % (n/N) <sup>b</sup>	95.9% (2988/3116)	95.6% (3037/3177)	94.8% (3013/3178)	94.8% (3023/3188)
Plasma HIV RNA $\leq$ 50 copies/ml in on-treatment analysis, % (n/N) <sup>a</sup>	94.9% (2925/3080)	94.9% (2962/3122)	95.3% (2927/3070)	93.9% (2905/3093)

(continued on next page)



**Table 1** (continued)

Total patient number, n=	2018	2019	2020	2021
	3116	3177	3178	3188
PVL<50 copies/ml in modified intention-to-treat population, % (n/N) <sup>b</sup>	93.8% (2925/3116)	93.2% (2962/3177)	92.1% (2927/3178)	91.1% (2905/3188)

<sup>a</sup> On-treatment analysis by including only those who were receiving ART and had undergone PVL testing in each study year.

<sup>b</sup> Modified intention-to-treat analysis by including all PLWH receiving ART in each study year. In this analysis, those PLWH who had not undergone PVL testing were considered to have virologic non-suppression in the respective estimation of viral suppression defined as PVL <50 copies/ml or <200 copies/ml.

Abbreviations: ART, antiretroviral therapy; HCV, hepatitis C virus; IDU, injection drug users; IQR, interquartile range; MSM, men who have sex with men; PLWH, people living with HIV; RPR, rapid plasma reagin; SD, standard deviation.

sought care at this hospital had decreased from 85 and 86 in 2018 and 2019, respectively, to 55 and 53 in 2020 and 2021, respectively. The median CD4 count at HIV diagnosis of those people newly diagnosed with HIV infection had decreased from 278 and 259 cells/mm<sup>3</sup> in 2018 and 2019, respectively, to 222 and 257 cells/mm<sup>3</sup> in 2020 and 2021, respectively; and the proportion of those who had CD4 counts <200 cells/mm<sup>3</sup> at HIV diagnosis remained high, 35.3%, 36.0%, 45.5%, 35.8% in 2018, 2019, 2020, and 2021, respectively (*p* for trend, 0.38). The interval (median [IQR], days) between confirmed HIV diagnosis to ART initiation had shortened from 5 (IQR, 2–7) to 0 (IQR, 0–1) days in 2018–2021 (Table 1). Overall, 85.7% (239/279) started ART within 7 days of HIV diagnosis for all people newly diagnosed with HIV during the four study years; and 24.7% (69/279) started ART on the same day of HIV diagnosis. The percentage of people newly diagnosed with HIV infection and started ART on the same day of HIV diagnosis had increased from 11.3% in 2018 to 69.8% in 2021.

### Trends of retention in care among PLWH

During the 4-year study period, a total of 3420 PLWH sought HIV care. At the end of 2018, 3116 continued to receive care at NTUH. The rate of discontinuation of HIV care of

those having sought HIV care in 2018 was 3.7% in 2019, which remained unchanged in 2020 (3.7%) and 2021 (3.8%) (Table 2). Overall, 88 (2.6%) PLWH who stayed abroad had their ART refilled and delivered with the assistance of their families, friends, or volunteer workers of NGOs in 2019–2021.

### Trends of HIV-related testing

In addition to ART refills and the rates of loss to follow-up, we used the numbers of RPR, CD4 count and plasma HIV RNA testing as surrogates for HIV care delivery during the 4-year study period (Table 1). Before the pandemic, the total number of RPR tests performed for syphilis was 7816 in 2018 and 7895 in 2019, which had decreased to 7545 in 2020 and 7207 in 2021. The total numbers of anti-HCV antibody or HCV RNA testing were 3216 and 4276 in 2018 and 2019, respectively, which had increased to 4783 in 2020 and 4823 in 2021. The average number of anti-HCV antibody or HCV RNA testing for each individual per year had increased from 1.03 in 2018 to 1.51 times in 2021. The proportion of PLWH without anti-HCV or HCV RNA testing had decreased from 33.3% in 2018 to 7.8% in 2021 (Table 1). The total numbers of plasma HIV RNA testing were 7927 and 7839 in 2018 and 2019, respectively, which had decreased to 7509 in 2020 and 7205 in 2021. However, the proportions of plasma HIV RNA ≤200 copies/ml in the on-treatment populations were similar, 97.0% in 2018, 97.3% in 2019, 98.1% in 2020, and 97.7% in 2021, so were the rates of plasma HIV RNA ≤50 copies/ml in the modified intention-to-treat populations for the four study years (Table 1).

### Discussion

In this retrospective observational study, we showed that the number of HIV screening tests performed at VCT service had significantly decreased by nearly 40% after the Covid-19 outbreak in 2020 and 2021. During the 4-year study period, the annual rates of loss to follow-up remained stable (3.7–3.8%). While the total annual number of plasma HIV RNA testing had decreased from 7927 in 2018 to 7205 in 2021, the rates of viral suppression among those who had their plasma HIV RNA determined remained high. Despite the negative impact of Covid-19 outbreak on HIV testing and HIV care delivery, the intervals from HIV diagnosis to

**Table 2** Disposition of people living with HIV seeking care at the National Taiwan University Hospital in 2019–2021.

N	2019	2020	2021	All
	3177	3178	3188	3420
Transfer of care to other hospitals, n (%)	55 (1.7)	47 (1.5)	49 (1.5)	151 (4.4)
Staying abroad, n (%)	10 (0.31)	10 (0.31)	12 (0.31)	32 (0.94)
Loss to follow up, n (%)	32 (1.0)	39 (1.2)	43 (1.3)	114 (3.3)
Death, n (%)	15 (0.5)	12 (0.4)	15 (0.5)	42 (1.2)
Incarceration, n (%)	7 (0.2)	9 (0.3)	5 (0.2)	21 (0.6)
Discontinuation of care, n (%)	119 (3.7)	117 (3.7)	124 (3.8)	360 (10.5)

ART initiation continued to shorten with the introduction of immunochromatographic assay to facilitate rapid confirmation of HIV infection and single-tablet antiretroviral regimens to improve adherence and tolerability in Taiwan.<sup>22</sup>

Covid-19 pandemic could have negative impact on HIV care delivery and result in the increases of the number of HIV late presenters, STIs and new HIV infections.<sup>11</sup> The finding of significant decreases of HIV testing provided at hospital-based VCT service in our study was similar to those observed in previously studies.<sup>4,6</sup> During the pandemic, access to testing could be significantly hindered because of restrictions on entry into the hospital and lockdown; moreover, people may have concerns about contracting SARS-CoV-2 during traveling to the hospitals or at the hospitals. Delays in seeking HIV testing may increase the risk of late presentation of HIV infection, as shown in the observational study in the Netherlands, which demonstrated a higher proportion of late presentation among the new HIV referrals after lockdown due to Covid-19 outbreak.<sup>5</sup> In this study, we found that the proportions of people newly diagnosed with HIV infection who presented with CD4 counts <200 cells/mm<sup>3</sup> were 35%–36% in 2018–2019 to 36–46% in 2020–2021 (p for trend, 0.38). Delayed HIV diagnosis may potentially increase the risk of HIV transmission, and late presentation may also increase the risk of developing opportunistic illnesses and mortality and the medical expenditure in managing the opportunistic illnesses. To overcome the adverse impact of Covid-19, programs and strategies have been developed, including telephone screening of clients for COVID-19 symptoms before they visit testing services, syndromic management of STIs symptoms by telemedicine, and home-based self-testing for HIV and STIs under the supervision of program staff in the USA.<sup>12</sup>

Previous studies have shown that ART initiation, clinic visits, plasma HIV RNA testing and virologic suppression among PLWH decreased during the Covid-19 pandemic.<sup>4,7</sup> The HIV testing and ART initiation were most affected due to a paucity of personal protective equipment and space for physical distancing in clinics, as well as shortened clinic opening hours and staff being redeployed from HIV testing to Covid-19 response activities.<sup>4,27</sup> To minimize the disruptions on ART, differentiated service delivery programs were implemented and the clinics and pharmacies were able to facilitate ART provision through strategies such as multi-month dispensing and ART provision outside of conventional healthcare facilities.<sup>12,28</sup> During the Covid-19 pandemic, the development of alternative options for health care delivery was accelerated, which included telemedicine, scheduled facility-based appointments, home-base appointments, extended ART dispensation/refill, ART dispensation at satellite clinics, and home delivery of drugs. In our study, we found that the disruptions to ART initiation, hospital- or pharmacy-based ART refills and clinic visits were minimal. Although our infectious diseases physicians were the main task force to be in charge of infection control and care of people with COVID-19 in Taiwan, these same infectious diseases physicians continued to provide HIV care services in collaboration with

HIV case managers, consultation staff and researchers for PLWH. While the numbers of plasma HIV RNA testing decreased for two consecutive years into Covid-19 pandemic, the rates of viral suppression remained high and the rates of discontinuation and loss to follow-up remained low throughout the four consecutive study years. Moreover, rapid and same-day ART initiation programs implemented were not affected for those who newly received HIV diagnosis.

Our study showed reductions in the numbers of RPR testing among PLWH. While it is not clear whether lockdown or social distancing would have any impact on the acquisition of STIs, the decreases of RPR testing raised concerns about delay in detection of syphilis and other STIs. However, we found that the numbers of HCV testing, including anti-HCV antibody and HCV RNA testing, continued to increase in 2018–2021. Because Taiwan government has committed to HCV elimination by 2025, implementation of HCV testing programs and improvement in accessing DAA treatments by lifting the restrictions might have encouraged health care providers to perform HCV testing.<sup>29</sup> The implementation of pooled-plasma HCV RNA testing program among high-risk PLWH at our hospital would increase the numbers and proportions of PLWH undergoing HCV testing after 2019.<sup>26</sup> Our recent finding of declining incidence and prevalence of HCV viremia among PLWH at this hospital following the implementation of the HCV elimination program of free access to DAA treatments suggests that Covid-19 did not have negative impact on our progress toward HCV microelimination.<sup>30</sup>

There are several limitations to our study. First, it was an observational study conducted at a single center. While the HIV care follows the national treatment guidelines and HIV care, including ART and laboratory testing, and is fully reimbursed, our findings among PLWH with few injecting drug users might not be generalizable to other designated hospitals for HIV care around Taiwan. Second, the case number of Covid-19 recorded in Taiwan remained relatively smaller compared to those in other countries during the study period, which might be contributory to the relatively minimal impact observed on HIV care delivery. Our observation in Taiwan could not be generalized to those in other settings where medical facilities were overwhelmed in providing care to people with Covid-19. Third, the impact of significant decreases in HIV testing at VCT service needs further attention, though the government has increased the distribution of HIV testing kits through the vending machines and convenient stores islandwide. Fourth, this current study spanned 2018–2021 and did not include 2022; therefore, the findings observed in this study might not be generalizable to the situation in 2022, when Omicron variants have become predominant.

In conclusion, our study showed that the Covid-19 pandemic has led to reductions of the numbers of HIV screening testing at VCT service and the numbers of most HIV care-related testing; however, the programs of rapid and same-day ART initiation, continuity of ART and achievement of viral suppression with ART appeared to be minimally affected by Covid-19 in Taiwan.

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## Ethical approval statement

The study was approved by the Research Ethics Committee (registration number, 202111018RIND).

## Declaration of competing interest

None of the authors has known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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