

# SARS-CoV-2 and HIV: Epidemiology, Treatment, and Lessons Learned from HIV

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## Abstract

**Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of COVID-19, was first detected in China in December 2019 and has rapidly spread throughout the world. Globally, the impact of COVID-19 has been severe with more than half a million deaths over 6 months; in contrast, the HIV pandemic has resulted in over 32 million deaths worldwide over 40 years. This paper reviews the current epidemiology of COVID-19, summarizes its relationship to HIV, identifies synergies in our response, and suggests actions that can be taken to curtail the spread of COVID-19 among persons living with HIV (PLWH). Our understanding of the epidemiology, clinical presentation, prevention, and treatment of COVID-19 has evolved rapidly as they did with HIV. Epidemiologically, there are similarities between the two viruses including asymptomatic spread, disproportionate impact on persons of color, need for rapid diagnostic testing, and lack of a cure or vaccine. PLWH do not appear generally to have an increased incidence of COVID-19 infection or a more severe course of disease. Clinical trials to identify potential treatment and prevention options for COVID-19 have included antiretrovirals used to treat HIV that have not been efficacious. Public health responses overlap between the two pandemics including the need for behavior change and containment strategies such as contact tracing. As the SARS-CoV-2 pandemic evolves, the path forward to controlling, preventing, and treating COVID-19 can be informed by lessons learned from HIV as we seek to control the spread of both viral pandemics. (AIDS Rev. 2020;22:133-142)**

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## Key words

**HIV. Pandemic. SARS-CoV-2. COVID-19. Epidemiology.**

## Introduction

Only months ago in December 2019, a pneumonia of unknown origin was detected in Wuhan China<sup>1</sup>. Within days, the etiology of this pneumonia would be determined to be severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes

COVID-19<sup>2</sup>. Despite efforts by the Chinese government to rapidly contain the virus, the World Health Organization (WHO) declared a public health emergency of international concern in January 2020 and a global pandemic in March 2020<sup>3,4</sup>. Globally, the impact of COVID-19 has been severe and devastating with more than 10 million cases of COVID-19 diagnosed

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globally and over 500,000 deaths through June 2020<sup>5,6</sup>. While the virus emerged in China, the United States (US), Brazil, India, and Russia have been epicenters of transmission, all reporting the greatest numbers of cases.

Unfortunately, there have been multiple viral pandemics in the last century, including the 1918 Spanish influenza, the 1957 Asian Influenza, the 1968 Hong Kong Influenza, the 2009 H1N1, and the 2015 Zika virus pandemic, with global spread resulting in numerous infections and deaths. The HIV pandemic has resulted in over 32 million lives lost<sup>7</sup> and has many similarities and differences with SARS-CoV-2. These other viruses can inform our responses to the current COVID-19 pandemic due to their global nature and challenges in treatment and prevention<sup>8,9</sup>. This paper seeks to describe the epidemiology of COVID-19 as it is understood to date, summarize what is known about its relationship to HIV, identify synergies in our response and suggest actions that can be taken to curtail the spread of COVID-19 among persons living with HIV (PLWH).

## **Epidemiology and clinical presentation of SARS-CoV-2**

Our understanding of the epidemiology of SARS-CoV-2 has evolved with the emergence of the pandemic. The virus is a member of the *Coronaviridae* family, which includes SARS-CoV, the cause of SARS, and MERS-CoV which causes Middle East Respiratory Syndrome. The natural reservoir of the virus is thought to be in bats, with spillover occurring into humans through exposure at wet markets<sup>10</sup>. Transmission occurs primarily through respiratory droplets with some transmission occurring through contact with infected surfaces<sup>11,12</sup>. While our understanding of the virus is dynamic and continuously evolving, it is noteworthy how rapidly the global scientific community has identified and shared critical information key to informing treatment and prevention.

### **Transmission**

After exposure to SARS-CoV-2, the median incubation period is 4-5 days (range 2-14 days)<sup>13</sup> with an estimated 35% of persons having asymptomatic infection<sup>14</sup>. Among those who are symptomatic, 80% experience mild-to-moderate illness; whereas 15% of infected persons require hospitalization and 5% may become critically ill<sup>15</sup>. The duration of illness is

generally 1-2 weeks when mild but prolonged among those with severe illness. Viral shedding is believed to be highest in the 48-h period before symptom onset and may persist for more than 35 days<sup>16</sup>. The estimated reproductive number ranges from 2 to 6.5<sup>17</sup> with a 7-12% secondary attack rate among household contacts<sup>18</sup> and 12-82% attack rate in congregate settings such as nursing homes, prisons, and homeless shelters<sup>19-21</sup>.

### **Clinical presentation**

The clinical syndrome caused by SARS-CoV-2 is called COVID-19. Clinically, COVID-19 presents as a constellation of symptoms including fever, myalgia, cough, dyspnea, sore throat, and gastrointestinal illness including vomiting, diarrhea, anorexia, and abdominal pain, anosmia and dysgeusia, rhinorrhea and dizziness, and rash including chilblains<sup>2,22,23</sup>. Severe illness with COVID-19 has included a range of clinical outcomes including the development of pneumonia, acute respiratory distress syndrome, a hyperactive or excessive immune response characterized as a cytokine storm in adults,<sup>2,24</sup> and multi-system inflammatory syndrome among the pediatric population<sup>25</sup>.

### **Risk factors**

Persons at higher risk for severe COVID-19 include those ages 65 and older, and persons with underlying medical conditions including hypertension, cardiovascular disease, diabetes, chronic respiratory conditions, obesity, renal disease, and autoimmune or immunosuppressive conditions such as HIV<sup>26,27</sup>.

In the US, studies have shown that racial/ethnic minorities are also at substantially higher risk for infection and death, likely due to socioeconomic conditions such as living in multi-generational households or employment in occupations considered to be essential, and severe illness which has been attributed to a higher prevalence of underlying conditions coupled with systemic inequities in health-care access and treatment<sup>28,29</sup>. Similar racial disparities have also been observed in the United Kingdom<sup>30</sup>.

### **Diagnostics**

The diagnosis of COVID-19 infection has primarily relied on the detection of viral RNA from nasal swabs using PCR<sup>31</sup>; however, diagnostic technologies have rapidly emerged to include antigen tests, as well as

serological testing for IgG<sup>32</sup>. Despite the advent of new testing technologies, questions remain as to whether the presence of antibodies will confer immunity and if so, its association with antibody levels and the duration of immunity. In addition, innovative testing approaches, akin to those currently available for HIV, have also emerged including rapid tests, saliva-based tests, self-testing, and home-based testing approaches<sup>33,34</sup>. New methods of specimen collection that is less invasive are currently under development as well as novel approaches such as micropooling, which is done for acute HIV screening in select areas<sup>35</sup>.

## **Treatment**

Treatment for COVID-19 is mainly supportive for those with mild-to-moderate illness with most individuals able to recover at home. However, for those with more severe infection, extensive research has already been conducted to identify effective therapies<sup>36</sup>. Treatments under consideration have included hydroxychloroquine, lopinavir/ritonavir, interferon beta 1a, dexamethasone, and remdesivir. Importantly, investigation into the use of antiretrovirals (ARVs) used for HIV treatment has also been explored as potential therapeutics for COVID-19. In one study of lopinavir/ritonavir, the authors concluded that its use did not significantly reduce the time to clinical improvement, nor reduce mortality<sup>37</sup>. Similarly, studies of darunavir have been conducted for prevention purposes but were not determined to be effective<sup>38</sup>. Thus far, the only approved treatment for COVID-19 is remdesivir which received emergency use approval by the US Food and Drug Administration and has been approved as treatment by other international licensing agencies in Europe and Asia<sup>39,40</sup>.

## **Prevention and public health responses to COVID-19**

Responses to the COVID-19 pandemic have relied on traditional public health approaches aimed at identifying persons who were infected, slowing transmission to prevent new infections, particularly among the most vulnerable, and protecting the health-care system infrastructure. Containment strategies such as testing, case investigation, contact tracing, and isolation and quarantine are the mainstay of the response early in a local epidemic, however, as transmission of the virus outpaced containment efforts, the response pivots toward a reliance on structural and policy-level mitigation

approaches such as school and business closures, face coverings and mask use, and social distancing.

Globally, the response to the pandemic has been variable with some countries instituting packages of restrictions including rapid scale up of widespread testing followed by immediate isolation and quarantine, travel restrictions, and country-wide stay at home orders, whereas as other countries have chosen to forgo stay at home orders and school closures while encouraging social distancing and mask wearing. These disparate approaches have resulted in varying case counts, seroprevalence, hospital resource allocation and access, and numbers of deaths.

The responses to the pandemic in the US, South Korea, Sweden, Singapore, and South Africa, all highlight the variability in response and outcomes. In the US, there has been heterogeneity in the approaches used by state and local jurisdictions to testing, institution of non-pharmaceutical interventions such as mask wearing, and adherence to the US Government's "gating criteria" for re-opening<sup>41</sup>. This has resulted in resurgences of COVID-19 cases in the majority of US states and significantly lower case rates in others<sup>5</sup>. In South Korea, the government built its response off of the MERS outbreak in 2015 and instituted widespread rapid testing which reached over 10,000 people per day and allowed for rapid quarantine and isolation and an estimate of the overall prevalence of COVID-19 in the country<sup>42</sup>. These activities coupled with mask wearing and public messaging around disease prevention have resulted in < 60 cases reported on a daily basis as of early July 2020<sup>5</sup>. The Swedish government, on the other hand, took what was considered a more liberal approach. The government did not issue any stay at home orders but did prohibit public gatherings of larger than 50 people and visits to nursing homes and encouraged social distancing in restaurants. Secondary schools and universities transitioned to online learning while primary schools and daycare centers remained open. This approach resulted in over 5400 deaths to date and an estimated 7% herd immunity<sup>43</sup>. Contrary to Sweden's approach, Singapore activated its pandemic preparedness plan which it had developed in response to the SARS pandemic. Response activities included conducting enhanced surveillance and screening for pneumonia and influenza-like-illnesses, instituting quarantines and mandatory isolation in dedicated infectious disease public health facilities and deploying bluetooth-enabled contact tracing applications<sup>44</sup>. Despite occasional clusters which have been rapidly contained, this more aggressive response has

led to only 26 reported deaths in Singapore<sup>5</sup>. Finally, in South Africa, one of the first countries in sub-Saharan Africa to report a case of COVID-19, a national state of emergency was declared inclusive of a 21-day lockdown which resulted in a precipitous drop in cases. The South African government also deployed more than 28,000 community health workers to conduct active case finding through COVID-19 screening and testing<sup>45</sup>. South Africa has tested more than 20% of its population<sup>45</sup> and reported < 3000 deaths as of the end of June 2020<sup>5</sup>.

## SARS-CoV-2 and HIV

When examining data from SARS and MERS among PLWH, infection rates were relatively low and the disease course was mild<sup>46</sup>, thus, it was unclear how SARS-CoV-2 would impact PLWH. Early in the pandemic, it was hypothesized that since many PLWH are aging with HIV and have co-occurring health conditions they may have been predisposed to a more severe disease course. Globally, an estimated 21% of the 38 million PLWH are 50 years of age or older and commonly observed comorbidities among PLWH include cardiovascular disease, essential hypertension, and metabolic disorders such as dyslipidemia, and chronic respiratory diseases such as chronic obstructive pulmonary disease, and endocrine disorders such as diabetes cancers, and chronic liver disease--conditions which have been directly attributed to an increased risk of COVID-19 severe infection<sup>47,48</sup>.

Initial case reports of PLWH who were infected with COVID-19 reported relatively mild disease among those who were on ARVs, virally suppressed and had CD4 counts > 200 cells/ $\mu$ L, with high rates of recovery<sup>49-62</sup>. A review of ten case series with five or more PLWH diagnosed with COVID-19 (Table 1) demonstrated a low incidence (< 2%) of COVID-19 among PLWH at < 2%<sup>63-65</sup>. The median age of coinfecting persons was over 50 years of age and many were on ARVs, were virally suppressed, and had comorbidities<sup>63,64,66-68</sup>. Clinically, PLWH had mild-to-severe respiratory infections and while some required intubation, most survived<sup>63-67,69-73</sup>.

While larger and more systematic studies of COVID-19 among PLWH are needed to better understand the trajectory of illness, several of these initial studies suggest that PLWH are not at increased risk of COVID-19 and may in fact be at a slightly lower risk than the general public<sup>63,66,71</sup>. Given the surprisingly mild clinical course of infection among PLWH, it has

been posited that immunosuppression or perhaps ARVs may be protective against severe illness with SARS-CoV-2<sup>66</sup>.

National and international HIV organizations have issued recommendations regarding the prevention and management of each condition among PLWH. The WHO, the US Centers for Disease Control and Prevention, and the US Department of Health and Human Services have issued guidance that emphasizes the need for continuity of HIV care, including uninterrupted access to HIV medications, encouraging routine vaccinations, providing access to care through telehealth and maintaining social networks and support while physically distancing to prevent infection<sup>74-76</sup>.

The impact of the COVID-19 pandemic on the HIV care continuum is also being monitored. Results from a rapid online survey conducted among 1051 US MSM, 11.6% of whom were living with HIV, found that 33% of respondents said their HIV care visits had decreased, 20% had trouble making or keeping HIV appointments and getting viral load and other lab testing completed, while < 10% reported disruptions in access to ARVs or their ability to remain adherent since the start of the pandemic<sup>77</sup>. In contrast, in China, assessments of the care continuum identified gaps in linkage to care, access to ARVs, as well as a need for psychosocial supports such as mental health and stigma reduction<sup>78</sup>. Close monitoring of the impact of the pandemic on HIV treatment and prevention services will be critical as we move into the next phase of the pandemic and may inform approaches to care delivery such as the role of telehealth or home-based testing for HIV, sexually transmitted infections (STIs), and viral load testing.

## Impact of COVID-19 on HIV prevention

The impact of COVID-19 on HIV prevention is also being examined, with concerns that this new pandemic may likely disrupt progress toward ending the epidemic<sup>79</sup>. Although social distancing might lead to a decrease in sexual or drug-related exposures to HIV, there are numerous ways in which COVID-19 could have a deleterious impact on HIV prevention. For example, with the closing of physicians' offices and outpatient clinics as part of efforts to slow the spread of SARS-CoV-2, many routine preventive services have been limited, creating considerable challenges in access. These closures have specifically affected access to HIV prevention services including HIV testing, free condom access, STI screening services, non-occupational post-exposure

**Table 1. Summary of five or more COVID-19 and HIV coinfecting patients published as of June 2020**

Author	Country	Sample size	Age	On ART	CD4 (cells/uL)	VL (cp/mL)	Outcomes
del Amo et al. <sup>67</sup>	Spain	236 PLWH diagnosed with COVID-19 among 77,950 PLWH	59% aged 50-79 years old	100%	Not reported	Not reported	151 patients were hospitalized, 15 were admitted to the ICU, and 20 died. Men and persons > 70 years old had a greater risk for diagnosis of and hospitalization for COVID-19. Patients receiving TDF/FTC had a lower risk of COVID-19-related hospitalization compared to patients on other ART.
Vizcarra et al. <sup>63</sup>	Spain	51 PLWH Compared 51 PLWH with HIV/ COVID co-infection to 1288 HIV non COVID-infected sample (1.8%)	53.3 (mean)	100%	47% < 200	Not reported	63% with at least one comorbidity. Similar clinical presentation to general population. 55% required admission (n = 28); 23 managed as outpatients, 44 recovered. 6 (12%) critically ill, two died.
Gervasoni et al. <sup>66</sup>	Italy	47 PLWH cases identified from a registry of 6,000 PLWH	51 (mean)	100%	636	94% < 20	64% with at least one comorbidity, 45 (96%) fully recovered, 28 required hospitalization, two intubated, two died. No greater risk of severe disease or infection and perhaps slightly lower than the general population.
Hu et al. <sup>69</sup>	China	12 PLWH surveyed	36 (median)	83%	500	80% undetectable	4 participants reported comorbidities. Nine of ten PLWH on ART had mild COVID-19 symptoms. Two admitted to ICU were ART naive. One PLWH died. Six of 11 coinfecting PLWH reported depression.
Harter et al. <sup>72</sup>	Germany	33 PLWH identified at 12 HIV centers and conducted retrospective case review	48 (mean)	100%	Median 670	94% VL < 50	60% had at least one comorbidity. Three patients died (9%), 91% recovered and 76% had mild illness, no excess morbidity or mortality; two viremic patients-required ICU and ventilation, one of whom died.
Shalev et al. <sup>64</sup>	USA (NY)	31 hospitalized patients identified from HIV registry among 2159 patients with lab confirmed COVID (1.4%)	60.7 (mean)	100%	Mean 396	97% with VL < 200	71% had comorbidities (hypertension, diabetes mellitus, and obesity). 26% required ventilation, 74% survived, 26% deceased. No increased rates of hospitalization among PLWH.

(Continues)

**Table 1. Summary of five or more COVID-19 and HIV coinfecting patients published as of June 2020 (Continued)**

Author	Country	Sample size	Age	On ART	CD4 (cells/uL)	VL (cp/mL)	Outcomes
Okoh et al. <sup>71</sup>	USA (NJ)	27 PLWH co-infected with COVID-19	58 (median)	85%	median 551	96% VL < 120	COVID-19 presentation similar to that reported in the general population. All patients had well-controlled HIV and 59% had hypertension, 49% were hospitalized; 23% required ICU admission. Survival among inpatients was 85%.
Childs et al. <sup>73</sup>	UK	18 PLWH who were hospitalized;	52 (median)	100%	395	94% < 50	Majority of patients black (94%) and 56% were obese. Two patients were treated with remdesivir, and the ART regimen for in two patients was switched to lopinavir/ritonavir. Five required ventilation; five patients died and 12 were discharged.
Suwanwongse et al. <sup>68</sup>	USA (NY)	9 hospitalized patients	58 (median)	89%	100% > 200	Range: undetectable -31	100% with comorbidities. All patients presented with fever, cough, and dyspnea; 89% had chest X-ray abnormalities characteristic of COVID-19 pneumonia; 7 patients died.
Blanco et al. <sup>65</sup>	Spain	5 PLWH among 543 cases (1%)	37.8 (mean)	80%	80% > 400	80% virologically suppressed	2 with URIs, 3 with viral pneumonia. One late diagnosis of HIV identified. Switched to PI based ART regimens. Two patients required admission to ICU and one required intubation; severe case was among 5 <sup>th</sup> case who was a late diagnosis of HIV (not intubated), no deaths.
Karmen-Tuohy et al. <sup>70</sup>	USA (NY)	21 hospitalized PLWH matched to 42 HIV-negative patients	60.0 (mean)	100%	median CD4 = 298	88% VS (n = 15/17)	33% with hypertension. Three patients had bacterial pneumonia and died. Compared to HIV-negative patients PLWH had a significantly higher absolute lymphocyte count and higher C-Reactive Protein on initial laboratory results.

PLWH: persons living with HIV; TDF/FTC: tenofovir disoproxil fumarate/emtricitabine; PI: protease-inhibitor; ART: antiretroviral therapy.

prophylaxis (nPEP), and HIV pre-exposure prophylaxis (PrEP). For people already taking PrEP, necessary HIV, STI, and renal function testing may be drastically reduced, limiting the ability to obtain refills of PrEP. For

those newly needing prescriptions for PrEP or nPEP, timely access may be eliminated, and community-based educational programming to encourage nPEP and PrEP uptake may be nonexistent.

**Table 2. HIV and SARS-CoV-2 pandemics – Comparisons**

<b>Virus</b>	<b>HIV</b>	<b>SARS-CoV-2</b>
Type of virus	Retrovirus	Coronavirus
Disease	AIDS	COVID-19
Animal host	Non-human primates	Possibly Bats
Year first reported	1981	2019
Location of first cases	US (California, New York)	Wuhan, China
Global infections	75 million (1981-2018, 37 years) <sup>7</sup>	10.5 million (December 2019-June 2020, 7 months) <sup>5</sup>
Global deaths	32 million (1981-2018, 37 years) <sup>7</sup>	500,000 (December 2019-June 2020, 7 months) <sup>5</sup>
Mortality rate	Very high if untreated <sup>7</sup>	About 5% of reported cases <sup>5</sup>
Countries with most cases	South Africa, Nigeria, India <sup>7</sup>	US, Brazil, Russia, India <sup>5</sup>
Primary modes of transmission	Sexual, parenteral, perinatal	Respiratory
Incubation period	Years	Days
Stigma	Yes	Yes
Testing	PCR, serology	PCR, Serology
Typical acute clinical symptoms	ARS	Fever, Cough, Dyspnea
Examples of disease manifestations	Opportunistic Illnesses and Malignancies	Pulmonary, Renal, Cardiac
Treatment	Highly effective antiretrovirals	Partially effective antivirals, steroids
Prevention	Testing, contact tracing, pre and post-exposure prophylaxis (PrEP, PEP), antiretrovirals, safe sex, safe injection, and transfusion practices	Testing, social distancing, masks, hand hygiene, contact tracing, isolation, quarantine
Vaccine	No	No

ARS: asymptomatic or acute retroviral syndrome; PrEP: pre-exposure prophylaxis; PEP: post-exposure prophylaxis; PCR: polymerase chain reaction.

Early surveys suggest that those already engaged in PrEP services may not have difficulty maintaining prescriptions or adherence<sup>77</sup>, but this may represent bias in data collection and reflect highly selected groups of participants. Younger people, women, and those without regular healthcare access may have increasing challenges in PrEP access or adherence. The impact of COVID-19 on HIV prevention will likely only be seen over time as incident infections do (or do not) emerge at a higher rate. As the pandemic progresses, innovative approaches to PrEP that are tailored for sub-populations will be necessary. These include home-based HIV testing and service delivery<sup>80</sup>, youth-focused<sup>81</sup>, and

monitoring of services in conjunction with HIV incidence, such as seen with nPEP<sup>82</sup>, home delivery of PrEP services<sup>83</sup>, or pharmacy-based approaches<sup>84</sup>. To preserve progress that has been made toward ending the HIV epidemic and to continue on this trajectory, strategies to support access to HIV prevention concurrent with COVID-19 prevention globally are urgently needed.

### **Synergies and lessons learned from HIV**

Despite uncertainty as to the relationship between COVID-19 and HIV, our public health and clinical responses to their prevention and treatment are

instructive (Table 2). First and foremost, spillover from animals into humans followed by rapid geographic spread, coupled with asymptomatic spread of both viruses has rendered detection and control of both SARS-CoV-2 and HIV more difficult. Importantly, while HIV requires contact with bodily fluids, the respiratory droplet spread of SARS-CoV-2 is even more challenging than HIV with respect to viral containment. Diagnostically, this has resulted in the rapid awareness of the importance of testing among asymptomatic persons, and on the development of highly sensitive testing assays. Implementation of robust and flexible surveillance systems to monitor the incidence of disease as well as identify those at highest risk, have also been essential in our response. Similar to HIV, as risk factors and clinical symptoms of COVID-19 become clearer, its case definition will need to be modified.

The role of contact tracing is a cornerstone for COVID-19 disease control and prevention, which builds off the experiences of contact tracing used for HIV and other STIs. Similar approaches to population-based behavioral changes have also been critical to curbing the spread of both SARS-CoV-2 and HIV. Both require behavioral change with the use of protective measures (i.e., masks vs. condoms), and barriers to behavioral change have been frequently encountered. The challenges associated with developing effective therapeutics and vaccines for SARS-CoV-2 have been informed by those in HIV. ARVs have been examined as possible therapeutic agents and there are parallels in the need for rapid diagnostics and treatments.

There are severe social and economic consequences of both HIV and SARS-CoV-2. Early in the HIV pandemic, AIDS was considered to be a disease of men who have sex with men and injection drug users; however, over time it became apparent that heterosexuals were also at risk. Similarly, SARS-CoV-2 infection was initially considered to be a disease primarily of older persons but it soon became apparent that all age groups are impacted. Whether due to lack of health-care access, concomitant medical conditions, poverty, living conditions, or other risks to health, HIV, and SARS-CoV-2 both tend to impact those already at risk of poor health the hardest and especially racial and ethnic minorities. SARS-CoV-2 also disproportionately impacts those who by virtue of low socioeconomic status or other situations are placed in high risk occupational work settings such as meat processing plants or institutional settings such as nursing homes and correctional facilities. The HIV and COVID-19

pandemics both resulted in stigmatization that unfortunately often emerges with novel infections; criminalization can be an important public health issue as well. The extent of and long-term effects of the psychosocial and structural burden of these syndemics are also important factors.

## Path forward

As the SARS-CoV-2 pandemic evolves, we will continue to confront challenges in its identification and control while we improve our understanding about its short- and long-term consequences. Epidemiologically, we will need to closely monitor the global impact of the virus, particularly on low- and middle-income countries that are home to millions of PLWH. We must continue to study viral immunity and seasonality to inform our predictions and preparation for ongoing waves of disease. Research on therapeutics and vaccines will continue at a rapid pace and yet we must balance the urgency of this research with sound scientific evidence and approaches that can rapidly change as new knowledge accrues. This includes conducting randomized controlled trials to adequately assess potential therapeutic treatments and future prevention approaches such as broadly neutralizing monoclonal antibodies and vaccines. We will need to systematically collect data on cohorts of PLWH to understand the role of age, viral suppression, ARVs, and comorbidities and importantly to assess the pandemic's impact on our ability to achieve the 90-90-90 goals and determine how to effectively deliver care in this new environment. Structurally, we need to integrate lessons learned from HIV and past pandemics to strengthen our investments in public health infrastructure and pandemic preparedness. Finally, the HIV and infectious disease community must partner with community stakeholders and policymakers to collectively advocate for structural and policy level changes that will address the racial/ethnic inequities, stigma, and discrimination that we have been reminded of during this pandemic.

## Conclusions

SARS-CoV-2 has rapidly migrated all over the world, much as HIV did almost 40 years ago. Given the synergies between SARS-CoV-2 and HIV, the path forward to controlling, preventing, and treating COVID-19 should be informed by our HIV experiences as we seek to control the spread of both viral pandemics.

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