

HIV and COVID-19: review of clinical course and outcomes

Lauren K. Barbera¹, Kevin F. Kamis², Sarah E. Rowan^{2,3,4},
Amelia J. Davis¹, Soraya Shehata¹, Jesse J. Carlson², Steven C. Johnson⁴
and Kristine M. Erlandson⁴

¹University of Colorado, School of Medicine, Aurora, CO, USA; ²Denver Public Health, Denver, CO, USA; ³Denver Health, Division of Infectious Diseases, Denver, CO, USA; ⁴University of Colorado, Department of Medicine, Division of Infectious Diseases, University of Colorado, Aurora, CO, USA

Background: Understanding the relationship between HIV and SARS-CoV-2 has important public health implications.

Objective: To summarize current research on COVID-19 among people with HIV (PWH) as published through 15 July 2021.

Methods: We conducted a search of PubMed, Scopus, preprint databases (medRxiv, bioRxiv), and the references of publications found using key terms relevant to COVID-19 ('COVID-19' OR 'SARS-CoV-2' OR 'coronavirus') AND to HIV ('HIV' OR 'Human Immunodeficiency Virus' OR 'AIDS' OR 'Acquired Immunodeficiency Syndrome'). We summarized all articles that reported data or opinions on SARS-CoV-2 and HIV coinfection.

Conclusions: Although many initial case series and cohort studies found no increased risk for SARS-CoV-2 infection or severe COVID-19 outcomes among PWH, recent studies have signaled an increased risk for severe COVID-19 disease progression even in the setting of well-controlled HIV. Whether this is due to the increased prevalence of comorbidities in PWH and other social determinants of health is unknown. These conflicting findings highlight the continued need for COVID-19 related research among PWH that addresses COVID-19 disease course as well as exacerbation of existing comorbidities already disproportionately represented among PWH.

KEYWORDS: Human immunodeficiency virus, SARS-CoV-2, COVID-19, coinfection

Introduction

When COVID-19, the disease caused by the novel coronavirus SARS-CoV-2, began to surface in late 2019 and early 2020, healthcare officials and providers assumed that individuals with Human Immunodeficiency Virus (HIV) infection and other immunocompromising conditions would be at particularly high risk of both acquisition and severe disease.¹ Without effective antiretroviral therapy (ART), HIV leads to depletion of CD4 T-lymphocytes, resulting in a weakened adaptive immune response.² In the presence of effective ART, the cellular immune response recovers to variable degrees; however, individuals with HIV appear to remain at greater risk for many infections, including pneumococcal pneumonia, influenza,

meningococcal disease, herpes virus infections, and tuberculosis.²⁻⁷

As COVID-19 precipitated widespread closures of businesses, schools, and community gatherings, healthcare agencies, and other critical operations scrambled to determine how to provide essential services to patients while protecting their employees. In an attempt to limit potential spread to patients and employees, many clinics converted to virtual or telephone-based visits.⁸ However, as businesses, schools, and healthcare facilities have gradually resumed in-person services, the ongoing risk for acquiring SARS-CoV-2 infection, or developing severe disease, remain somewhat elusive.

While increasing age, obesity, diabetes, and Black or Hispanic race/ethnicity have consistently been linked to acquisition and severe disease in U.S. populations, the role of other factors, such as HIV, in contributing to risk of COVID-19 acquisition and disease

Correspondence to: Kristine M. Erlandson, University of Colorado Hospital, 12605 E. 16th Ave, Aurora, CO 80045, USA. Email: kristine.erlandson@cuanschutz.edu

severity have been less certain.^{9–14} Furthermore, people with HIV (PWH) frequently have overlapping risk factors for COVID-19, often at rates higher than the general population. These risks include being male, Black or Hispanic, smoking, older age, and medical comorbidities.^{15–23} Lastly, despite effective ART, PWH have higher levels of inflammation, one of the key factors driving the development of severe respiratory disease, thromboembolic disease, and other poor outcomes with COVID-19.^{24,25} Parsing out the added risk of HIV with or without ART in the setting of these other epidemiologic and physiologic risks is therefore challenging.

Methods

To better understand what is currently known about the relationship between HIV and COVID-19 acquisition and disease severity, we conducted a search of PubMed, Scopus, preprint databases (medRxiv, bioRxiv), and the references of publications found using key terms relevant to COVID-19 ('COVID-19' OR 'SARS-CoV-2' OR 'coronavirus') AND to HIV ('HIV' OR 'Human Immunodeficiency Virus' OR 'AIDS' OR 'Acquired Immunodeficiency Syndrome') between 1 March 2020 and 15 July 2021. Of 2210 initial results we considered each study that reported data or opinions on COVID-19 among PWH, applying extra filters to access articles related to 'symptoms', 'severity', 'hospitalization', 'mental health', 'access to care', and 'ART'. This resulted in the 212 articles presented in this review. We then summarized the risk for acquiring COVID-19, presenting symptoms of COVID-19, severity of COVID-19 illness, and impacts on mental health and access to care during the COVID-19 pandemic. We also report findings on the effects of antiretroviral therapy on COVID-19 risk and outcomes for PWH.

Discussion

Are people living with HIV more likely to contract SARS-CoV-2?

Many experts initially considered individuals living with HIV as a vulnerable group with regards to SARS-CoV-2 infection due to a greater burden of some comorbidities, higher systemic inflammation despite effective ART, and some degree of immune alteration even among those on effective ART with immune reconstitution.^{26–32} Whether this is true remains unclear. PWH account for approximately 0.7% of the general population of adults in the world, and roughly 0.5–1.5% of COVID-19 cases in various COVID-19 case series and cohort studies.^{28,33–36}

One prospective cohort study of 5683 PWH observed a lower incidence of COVID-19 among PWH compared to the general population, suggesting a possible protective effect of HIV, ART, or less exposure through physical isolation and consistent use of personal protective equipment.³⁷ However, this study was limited in that it did not control for ART use. Multiple other prospective cohort studies, limited by their study sizes, have found similar rates of SARS-CoV-2 among PWH and the general population.^{38–41} A study from San Francisco of 4252 PWH suggested that PWH were more susceptible to SARS-CoV-2 infection than those without HIV.⁴² Numerous other confounders, however, may have explained these differences: for example, 8% of PWH in San Francisco experience unstable housing as compared to the 1% of the San Francisco general population.⁴² As of 28 July 2020, the Centers for Disease Control and Prevention concluded that based on the limited data available, PWH on effective ART appear to have a similar risk for acquisition of SARS-CoV-2 as people who do not have HIV.⁴³

It is important to note that multiple studies have attempted to distinguish the difference between test positivity and disease incidence. In a recent analysis of over 30,000 PWH in the USA, PWH were more likely to be tested for SARS-CoV-2 but did not have an increased percentage of COVID-19 positivity compared to individuals without HIV.⁴⁴ However, the authors note that testing shortages and the potential for differential adherence to stay-at-home guidance by immunosuppression status could have influenced the outcome of the study. In contrast, researchers in Southern Italy found that PWH were more reluctant to obtain SARS-CoV-2 testing and thus were likely underdiagnosed with COVID-19, though this was an opinion piece and the conclusion was not backed by data.⁴⁵

Do the presenting symptoms of COVID-19 differ among people with or without HIV?

In the general population, the most common presenting symptoms of COVID-19 include fever, cough, or shortness of breath (70%) and less commonly muscle aches (36%), headaches (34%), and loss of smell or taste (8%).⁹ A cohort of 286 PWH showed similar symptoms: cough (76.2%), fever (70.7%), and fatigue (66.0%).²⁰ This study was especially strong as it took data from multiple states and countries. These results have been supported by numerous other studies.^{46–53} Besides one review, these studies are limited in their small sample size. Of note, other individual case studies have found that PWH may present with COVID-19

and opportunistic infections such as *Pneumocystis jirovecii* pneumonia and AIDS-related disseminated histoplasmosis, perhaps exacerbated by or contributing to presenting symptoms of COVID-19.^{54–60}

Are people living with HIV more likely to present with severe disease and/or be hospitalized for COVID-19?

Similar to the general population, age and co-morbidities appear to be the strongest predictors of severe disease and mortality in PWH.^{22,46,61–73} Most PWH who develop symptomatic COVID-19 have at least one comorbidity, most commonly hypertension, dyslipidemia, or type 2 diabetes mellitus.^{28,38,46,51,61,64,74–78} Per Dandachi et al. ($n = 286$), 81% of PWH had at least one co-morbidity which impacted their COVID-19 clinical course.²⁰

Data describing the likelihood of hospitalization due to COVID-19 among PWH is limited and mixed: rates of hospital admission among people living with HIV range from 0.8% to 1.8%.^{33,38,74,79} Notably, these rates derive from cohorts in numerous countries including Spain, China, and the United States, which may differ demographically with varying rates of comorbidities and clinical threshold for hospitalization. A retrospective, matched cohort study at a New York health system indicated PWH ($n = 21$) had a significantly higher rate of hospital admission but not intensive care unit admission, mechanical ventilation, or mortality, compared to people without HIV ($n = 42$).⁸⁰ All PWH in this cohort were on ART, the majority had an undetectable viral load, and only six of 19 had a CD4 count < 200 cells/uL, thus limiting the ability to determine the effect of HIV severity of COVID-19 outcomes. A separate small analysis of 31 PWH hospitalized at a New York, NY hospital also found similar rates of hospitalization among those with or without HIV.³⁵ In a much larger Veteran cohort of 107,636 patients with COVID-19, risk of hospital admission among PWH did not differ from those without HIV, although these results have not yet been published in a peer-reviewed paper.⁴⁴

In a retrospective study in New York comparing 21 PWH with 42 matched-uninfected controls admitted with COVID-19, a similar burden of comorbidities and similar admission laboratory values were seen between PWH and uninfected controls.⁸⁰ In addition, no statistically significant differences were seen between PWH and the uninfected controls when comparing consolidation, infiltrate, or opacity on chest imaging.⁸⁰ Although the study was small, findings are strengthened by matching PWH and controls by admission date, age, body mass index, gender, tobacco history, and a

history of chronic kidney disease, hypertension, asthma, chronic obstructive pulmonary disease, and heart failure. In summary, among PWH, risk factors for hospitalization and clinical presentation at the time of hospitalization appear to be influenced more by comorbidities or demographic risk factors seen in the general population (race/ethnicity, socio-economic status), and less by HIV-specific factors.

Are people with HIV more likely to have severe outcomes?

A number of studies on HIV and SARS-CoV-2 coinfection have addressed the question whether PWH have more severe outcomes than the general population (as defined by more ICU admissions, greater need for mechanical ventilation, and higher mortality rates). As summarized in [Table 1](#), many large studies and smaller case reports have found greater likelihood of ICU admission and higher mortality rates among PWH than the general population.^{76,81–91} Indeed, of 3,460,932 patients in the public sector in South Africa, 16% were PWH and 22,308 (0.6%) were diagnosed with COVID-19. In this large study, HIV infection was associated with a doubling of COVID-19 mortality risk, independent of CD4 count or HIV viral load (though $>90\%$ were virologically suppressed).⁹¹ In a study of 17,282,905 adults (including 27,480 PWH) in the United Kingdom, a substantially higher risk of mortality was seen with COVID-19 in PWH than in the general population, although the actual number of deaths among PWH was only 25, thus limiting some of the conclusions.¹⁹ Furthermore, data were available on some comorbidities and demographics but not HIV-related characteristics (ART, CD4 count, or viral load). A landmark report by the World Health Organization (WHO) included 15,522 PWH and 168,649 adults without known HIV hospitalized with suspected or confirmed SARS-CoV-2 from 24 countries (96% from the WHO African Region).⁹² HIV was associated with an increased risk of severe or critical disease at admission compared to uninfected controls, after adjusting for age, sex, and underlying comorbidities. HIV was also independently associated with higher mortality risk. The majority of persons included were from South Africa, and no data were presented on ART, CD4 count, or virologic suppression.⁹² Two systematic reviews/meta-analyses also concluded that PWH had a higher risk of mortality, though only in studies of PWH from Africa and the United States.^{93,94} A smaller study of PWH in Brazil ($n = 255$) found that being Black/Mixed race and having lower education were associated with greater mortality in adjusted models, while age, sex, CD4 count, viral load, and

Table 1. Summary of 2020–2021 publications (through 15 July 2021) related to HIV and COVID-19.

First author	Population	Location	Publication date	Journal	Description or findings
Zhu, F. ²⁶	1 PWH	China	11-Mar-20	J Med Virol	Described how PWH should be regarded as a vulnerable population in regard to COVID-19
Chen, J. ¹⁹⁹	1 PWH	China	14-Apr-20	J Med Virol	Described a coinfecting PWH with atypical CT imaging of the chest
Blanco, J.L. ³³	5 PWH	Spain	15-Apr-20	Lancet HIV	Described clinical course of patients (<50 years old)
Wang, M. ⁸²	1 PWH	China	23-Apr-20	Int J Infect Dis	COVID-19 and HIV (low CD4 count) led to a longer disease course
Aydin, O.A. ²³	4 PWH	Turkey	29-Apr-20	J Med Virol	Comorbidities are an important factor in mortality for coinfecting PWH
Ridgway, J.P. ⁴¹	8 PWH/1061 HIV negative controls	USA	7-May-20	AIDS Behav	PWH did not test positive for COVID-19 at a different rate than the general population
Härter, G. ⁴⁷	33 PWH	Germany	11-May-20	Infection	PWH did not have more severe morbidity or mortality than the general population
Gervasoni, C. ¹⁰⁵	47 PWH	Italy	14-May-20	Clin Infect Dis	PWH coinfecting with COVID-19 had favorable outcomes as compared to the general population
Patel, R.H. ¹⁰⁶	1 PWH	USA	22-May-20	J Med Virol	Coinfecting patient under treatment with ART had a less severe clinical presentation than the general hospitalized population
Iordanou, S. ⁸¹	1 PWH	Republic of Cyprus	25-May-20	J Med Virol	Coinfecting (PWH/COVID-19) patient had a prolonged need for mechanical ventilation and increased risk for thrombotic complications
Childs, K. ⁴⁹	18 PWH	United Kingdom	27-May-20	Clin Infect Dis	Black PWH were at higher risk of severe disease; ARTs did not appear to provide protection against COVID-19 severity
Vizcarra, P. ³⁸	51 PWH and COVID-19 positive/ 1288 PWH	Spain	28-May-20	Lancet HIV	Clinical presentation in PWH was similar to the general population, however, lower CD4 counts affected disease severity; PWH had a higher prevalence of comorbidities
Okoh, A.K. ¹⁴²	27 PWH	USA	28-May-20	J Acquir Immune Defic Syndr	Coinfecting PWH presented similarly to the general population
Ridgway, J.P. ⁵⁰	5 PWH	USA	29-May-20	AIDS Patient Care STDS	A similar COVID-19 clinical course was seen in PWH as in the general population
Shalev, N. ³⁵	31 PWH	USA	30-May-20	Clin Infect Dis	HIV coinfection did not lead to increased rates of hospitalization; outcomes for PWH were similar to the general population
Suwanwongse, K. ²⁷	9 PWH	USA	9-Jun-20	J Med Virol	PWH did not have more favorable COVID-19 outcomes especially when their CD4 counts were low
Coleman, H. ⁵⁵	1 PWH	United Kingdom	10-Jun-20	AIDS	<i>Pneumocystis jirovecii</i> pneumonia and COVID-19 infection were observed in a PWH
Karmen-Tuohy, S. ⁸⁰	21 PWH/42 HIV negative controls	USA	12-Jun-20	J Acquir Immune Defic Syndr	PWH had a higher admission rate for COVID-19 but did not show significant differences in ICU admissions, mechanical ventilator use, or mortality
Benkovic, S. ¹¹³	4 PWH	USA	16-Jun-20	J Med Virol	Clinical severity was not different in uncomplicated cases of

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
Byrd, K.M. ¹¹⁵	27 PWH	USA	19-Jun-20	J Int AIDS Soc	COVID-19 and HIV coinfection as compared to the general population
Meyerowitz, E.A. ⁷⁵	47 PWH	USA	25-Jun-20	AIDS	Clinical course and severity appeared similar in PWH as the general public
Del Amo, J. ²⁰²	236 PWH and COVID-19 positive/77,590 PWH receiving ART	Spain	26-Jun-20	Ann Intern Med	Coinfected PWH were on average 53.4 years old and a substantial proportion had comorbidities, were non-Hispanic Black, and lived or worked in a congregate setting
Sigel, K. ⁷⁴	88 PWH/405 HIV negative controls	USA	28-Jun-20	Clin Infect Dis	The risk for COVID-19 hospitalization was 20.3 among patients receiving TAF/FTC, 10.5 among those receiving TDF/FTC, 23.4 among those receiving ABC/3TC, and 20.0 for those receiving other regimens
Toombs, J.M. ¹²⁹	3 PWH	United Kingdom	29-Jun-20	J Med Virol	There was no difference in COVID-19 severity on admission by HIV status and PWH did not have more severe COVID-19 outcomes than the general population
Ho, H. ⁸⁴	72 PWH	USA	30-Jun-20	J Infect Dis	PWH may be protected from severe COVID-19 if they are on ART
Guo, W. ⁷⁶	14 PWH	China	1-Jul-20	J Int AIDS Soc	PWH were at higher risk for severe COVID-19 outcomes, especially those with increased markers of inflammation and immune dysfunction
Park, L.S. ⁴⁴	30,891 PWH/76,745 HIV negative controls	USA	6-Jul-20	AIDS 2020 Conference	HIV and COVID-19 coinfection led to a higher mortality rate and higher proportion of severe cases than the general population
Ruan, L. ¹⁰²	4 PWH	China	6-Jul-20	J Med Virol	PWH had higher COVID-19 testing rates but no evidence to support increased positivity or more severe outcomes
Gudipati, S. ¹¹²	14 PWH	USA	15-Jul-20	J Acquir Immune Defic Syndr	PWH in the stage of AIDS had a more complicated clinical course than those not in AIDS
Mahmood, K. ¹⁹⁶	1 PWH	USA	15-Jul-20	JACC Case Rep	PWH were not at a higher risk for severe COVID-19 outcomes
Cooper, T.J. ¹⁴⁰	70 PWH	United Kingdom	15-Jul-20	HIV Med	Coinfected PWH on a LVAD
Adachi, E. ¹⁴¹	2 PWH	Japan	15-Jul-20	AIDS	PWH with well-controlled disease are not at risk of poorer COVID-19 outcomes than the general population
Charre, C. ³⁹	77 PWH/27 PrEP users/19009 other patients	France	17-Jul-20	AIDS	Transgender PWH have similar clinical course of COVID-19 as compared to the general population
Maggiolo, F. ⁶¹	55 PWH and COVID-19 positive/69 PWH	Italy	24-Jul-20	J Med Virol	The positivity rate appeared similar in HIV-infected patients, in PrEP users, and in other patients
Su, J. ⁵²	1 PWH	China	1-Aug-20	AIDS	HIV coinfection did not protect from COVID-19 coinfection or from severe disease
Stoeckle, K. ¹¹⁶	30 PWH/90 HIV-negative controls	USA	1-Aug-20	Open Forum Infect Dis	Described COVID-19 in a patient with AIDS; speculated that protease inhibitors might have a protective effect for COVID-19

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
Sun, L.J. ¹¹¹	1 PWH	Singapore	1-Aug-20	J Acquir Immune Defic Syndr	A similar COVID-19 clinical course was seen in PWH as in negative controls
Calza, L. ⁴⁸	26 PWH	Italy	3-Aug-20	Infection	He recovered from a mild and uncomplicated clinical course of COVID-19 without treatment
Bhaskaran, K. ¹⁹	27480 PWH/17.3 million adults	United Kingdom	7-Aug-20	Lancet	PWH had a similar COVID-19 clinical presentation to the general population
Tian, C. ¹⁰⁸	1 PWH	China	10-Aug-20	Ann Palliat Med	PWH had nearly three-fold higher risk of COVID-19 death than those without HIV after adjusting for age and sex
Guo, W. ¹³⁸	11 PWH	China	10-Aug-20	Res Sq	Described favorable outcome in coinfecting PWH
Marbaniang, I. ¹⁵⁸	167 PWH	India	13-Aug-20	Res Sq	PWH have comparable COVID-19 morbidity rates as the general population,
Huang, J. ³⁴	35 PWH	China	17-Aug-20	Clin Infect Dis	1/4 of PWH had anxiety during the COVID-19 pandemic
Parker, A. ¹³⁶	24 PWH/92 HIV negative controls	South Africa	21-Aug-20	S Afr Med J	PWH had similar severity and fatality from COVID-19 as the general population
Boulle, A. ⁹¹	553,749 PWH	South Africa	29-Aug-20	Clin Infect Dis	Coinfecting PWH had similar presentations and outcomes as those without HIV
Larzabal, F.J. ⁷	1 PWH	Argentina	31-Aug-20	Medicina	HIV was independently associated with increased COVID-19 mortality
Molina-Iturriza, E. ¹³⁹	8 PWH	Spain	1-Sep-20	AIDS	Described a PWH hospitalized with <i>Pneumocystis jirovecii</i> and COVID-19 coinfection
Sasset, L. ⁷⁰	2 PWH	Italy	1-Sep-20	AIDS	The rate of COVID-19 in PWH is similar to the rate in the general population
Hu, Y. ¹⁹⁷	12 PWH	China	1-Sep-20	J Acquir Immune Defic Syndr	PWH had similar demographic and clinical characteristics to the general population
Shekhar, R. ¹¹⁰	5 PWH	USA	1-Sep-20	J Acquir Immune Defic Syndr	The value of ART for mitigation of COVID-19 infection is discussed
Madge, S. ¹¹⁷	18 PWH	United Kingdom	2-Sep-20	Sex Transm Infect	PWH may have a milder course of COVID-19 than the general population
Etienne, N. ⁶⁴	54 PWH and COVID-19 positive/4000 PWH	France	3-Sep-20	AIDS	PWH did not have prolonged hospital courses or worse outcomes compared to the general population
Inciarte, A. ³⁷	53 PWH and COVID-19 positive/5683 PWH	Spain	3-Sep-20	AIDS	PWH had worse COVID-19 outcomes when they were older age, male, had comorbidities, higher BMI, sub-Saharan Africa origins, had lower CD4 counts
Winston, A. ⁷⁷	699 PWH/304 HIV negative controls	United Kingdom and Ireland	3-Sep-20	AIDS	Incidence rate of COVID-19 was lower in PWH compared to general population; clinical course of COVID-19 was not dependent on any HIV- or ART-related factor
d'Ettore, G. ³¹	1 PWH	Italy	4-Sep-20	Medicine	PWH tended to have more comorbidities which was associated with poorer COVID-19 outcomes
Bertolini, M. ⁵⁴	1 PWH	Argentina	9-Sep-20	Int J STD AIDS	Coinfection of HIV and COVID-19 showed increased levels of IFN α/β and T-cell activation as compared to healthy individuals with COVID-19
					Described a male patient with AIDS-related disseminated

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
Dandachi, D. ²⁰	286 PWH	USA	9-Sep-20	Clin Infect Dis	histoplasmosis associated with COVID-19 PWH were at higher risk for severe COVID-19 outcomes, especially those with comorbidities and lower CD4 cell counts
Akyala, A.I. ¹⁹⁸	4 PWH	Nigeria	10-Sep-20	Pan Afr Med J	PWH experienced a mild COVID-19 clinical course
Nagarakanti, S.R. ¹¹⁴	23 PWH/23 HIV negative controls	USA	19-Sep-20	J Med Virol	Among, PWH, there was not higher mortality, ICU admissions, or mechanical ventilation in PWH than in the general population
Chiappe Gonzalez, A.J. ⁸³	1 PWH	Peru	21-Sep-20	Int J STD AIDS	HIV/COVID-19 coinfection led to a fatal outcome
Mondi, A. ¹²⁰	5 PWH	Italy	25-Sep-20	J Med Virol	PWH did not have more severe COVID-19 outcomes than the general population
Isernia, V. ⁷⁸	30 PWH	France	26-Sep-20	Int J Infect Dis	HIV was not a risk factor for COVID-19
Sun, S. ¹⁵⁰	703 PWH	China	Oct-20	AIDS Behav	PWH reported high rates of anxiety, depression, and insomnia
Collins, L.F. ⁴⁶	20 PWH	USA	1-Oct-20	AIDS	PWH with more than 5 comorbidities, who are non-Hispanic Black, are male had more severe COVID-19 outcomes
Di Biagio, A. ²⁰⁶	4 PWH	Italy	1-Oct-20	AIDS	Protease inhibitor-based regimens were not protective against contracting COVID-19 in PWH
Yamamoto, S. ²⁰⁰	5 PWH	Japan	2-Oct-20	J Microbiol Immunol Infect	PWH coinfecting with COVID-19 have a similar clinical course as patients without HIV
Kim, J.Y. ¹¹⁸	1 PWH	Korea	12-Oct-20	Korean Med Sci	PWH had a favorable clinical outcome with COVID-19
Gamboa, E. ¹²³	1 PWH	USA	17-Oct-20	Cureus	Noted that CD4+ lymphocytes declined over the course of COVID-19 hospitalization in a PWH
Zhang, J.C. ³²	2 PWH	China	19-Oct-20	BMC Infect Dis	Described the importance of accurate diagnosis for PWH with COVID-19 coinfection
Geretti, A.M. ⁸⁵	115 PWH/47,424 HIV negative controls	United Kingdom	23-Oct-20	Clinical Infectious Diseases	Following additional adjustment for disease severity at presentation, mortality was higher in PWH
Yang, R. ⁹⁷	3 PWH/53 HIV negative controls	China	27-Oct-20	Expert Review of Respiratory Medicine	Low CD4 count was a risk factor for severe COVID-19 outcomes
Cabello, A. ¹³⁷	63 PWH	Spain	27-Oct-20	Int J Infect Dis	Coinfected PWH do not have different outcomes based on severity of HIV or type of ARV treatment
Di Biagio, A. ⁹⁶	69 PWH	Italy	1-Nov-20	AIDS	Lower CD4 counts were associated with higher rates of COVID-19 hospital admission and more severe outcomes
Hadi, Y.B. ²⁸	404 PWH/49,763 HIV negative controls	USA	1-Nov-20	AIDS	Propensity-matched analysis showed no difference in outcomes for PWH compared to the non-HIV controls; higher mortality was related to comorbidities
Siewe Fodjo, J.N. ¹⁵⁷	317 PWH	Belgium, Brazil	1-Nov-20	J Acquir Immun Defic Syndr	23.3% of PWH screened positive for depression and 22.7% screened positive for anxiety during the COVID-19 pandemic
Morani, Z. ⁶⁹	43 PWH	Belize, USA	2-Nov-20		

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
				SN Compr Clin Med	Comorbidities and advanced age make PWH more prone to worse COVID-19 outcomes
Tesoriero, J.M. ⁹⁰	2988 PWH	USA	6-Nov-20	MedRxiv	PWH experienced poorer COVID-19 related outcomes than those without HIV
Jones, D.L. ¹⁶³	1554 PWH	Argentina, USA	18-Nov-20	Res Sq	PWH who had higher levels of social support reported less depression during the COVID-19 pandemic
D'Souza, G. ⁵³	2078 PWH/1333 HIV negative controls	USA	19-Nov-20	HIV Res Clin Pract	PWH had similar prevalence and type of COVID-19 symptoms as the general population
Sachdev, D. ⁴²	193 PWH and COVID-19 positive/4252 PWH	USA	20-Nov-20	J Acquir Immune Defic Syndr	PWH were more susceptible to COVID-19 than those without HIV
Turken, M. ⁹⁸	4 PWH	Turkey	30-Nov-20	Curr HIV Res	Two patients with normal CD4+ count had mild coinfections, a patient with low CD4+ count died
Braunstein, S.L. ¹⁰³	2410 PWH	USA	30-Nov-20	Clin Infect Dis	More PWH had adverse COVID-19 outcomes than the general population, perhaps due to comorbidities and other social determinants of health
Swaminathan, N. ¹⁴⁵	6 PWH	USA	1-Dec-20	J Med Virol	PWH had similar mortality when compared to other studies
Hardy, Y.O. ¹²⁷	3 PWH	Ghana	Dec-20	Ghana Med J	PWH with advanced immunosuppression may not have an unfavorable COVID-19 disease outcome
Kowalska, J.D. ¹²²	34 PWH	Central and Eastern Europe	13-Dec-20	Int J Infect Dis	HIV serostatus was not associated with more severe disease
Kuman Tuncel, O. ¹⁵⁹	307 PWH	Turkey	17-Dec-20	Turk J Med Sci	A significant proportion of PWH had anxiety during the COVID-19 pandemic
Hoffmann, C. ²⁰⁹	175 PWH	Germany, Spain, Italy	27-Dec-20	HIV Med	Virological suppression was possibly related to severe COVID-19 outcomes; no evidence of protective effect by ARTs
Noe, S. ¹³⁵	500 PWH	Germany	2-Jan-21	Infection	There were no marked differences for PWH with and without SARS-CoV-2 co-infection
Cooley, S.A. ¹⁵⁶	54 PWH/133 HIV negative controls	USA	6-Jan-21	J Neurovirol	PWH had increased symptoms of anxiety and depression during the COVID-19 pandemic
Laracy, J. ¹³²	68 PWH/272 HIV negative controls	USA	28-Jan-21	Open Forum Infect Dis	PWH did not differ from HIV-uninfected controls by rate of mechanical ventilation or death
Tesoriero, J.M. ⁸⁹	2988 PWH/2409 HIV negative controls	USA	1-Feb-21	JAMA Netw Open	PWH experienced poorer COVID-19 outcomes than the general population
Patel, V.V. ¹³⁴	100 PWH/4513 HIV negative controls	USA	1-Feb-21	Acquir Immune Defic Syndr	PWH had increased risk of intubation but similarly frequent rates of AKI and in-hospital death as those without HIV
Ceballos, M.E. ¹³³	36 PWH	Chile	3-Feb-21	Int J STD AIDS	No differences were found between PWH and the general population in the need for mechanical ventilation and death
Nasreddine, R. ⁶⁵	101 PWH	Belgium	9-Feb-21	J Med Virol	HIV patients with COVID-19 experienced a high degree of hospitalization
Delle Donne, V. ¹⁶²	98 PWH	Italy	1-Mar-21	Infez Med	Almost half of PWH experienced significant distress due to the COVID-19 pandemic

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
Eybpoosh, S. ¹²⁴	90 PWH	Iran	10-Mar-21	Med J Islam Repub Iran	HIV infection was not a risk factor for increased COVID-19 severity and death
Sorbera, M. ¹⁸³	211 PWH	USA	16-Mar-21	J Am Coll Clin Pharm	Telehealth for pharmacy services did not jeopardize patient outcomes
Weerasuria, M. ¹⁴⁹	153 PWH	Australia	17-Mar-21	AIDS Res Hum Retroviruses	Telehealth was widely used; many PWH experienced negative mental health in the COVID-19 pandemic
Farinacci, D. ⁵⁹	1 PWH	Italy	31-Mar-21	AIDS Res Hum Retroviruses	PWH coinfecting with <i>Pneumocystis jirovecii</i>
Durstenfeld, M.S. ¹²⁸	220 PWH	USA	7-Apr-21	MedRxiv	HIV was not associated with adverse outcomes of COVID-19
Mohindra, R. ¹³⁰	1 PWH/1 HIV negative control	India	7-Apr-21	Virus disease	PWH had a similar clinical course to HIV negative persons
Liu, W. ¹⁴⁶	1 PWH	Taiwan	21-Apr-21	J Formos Med Assoc	The clinical presentation of coinfecting PWH were similar to other COVID-19 patients without HIV infection
Diaz, M.M. ¹⁵³	156 PWH	Peru	26-Apr-21	MedRxiv	PWH reported increased anxiety and stress during the COVID-19 pandemic
Mang, S. ⁶⁰	1 PWH	Germany	26-Apr-21	Clin Infect Dis	PWH coinfecting with COVID-19 and <i>Pneumocystis jirovecii</i>
Siewe Fodjo, J.N. ¹⁵⁴	247 PWH	Brazil	27-Apr-21	Int J Environ Res Public Health	27.1% of PWH screened positive for anxiety, 27.9% screened positive for depression during the COVID-19 pandemic
Spinelli, M.A. ⁸⁷	955 PWH/1062 HIV negative controls	USA	29-Apr-21	Lancet HIV	PWH had more cases of severe COVID-19
Liang, M. ¹⁰⁴	7718 PWH/196,043 HIV negative controls	China	3-May-21	Infect Dis Ther	Coinfecting PWH were not associated with higher COVID-19 mortality
Merchant, E.A. ⁵⁸	1 PWH	USA	7-May-21	ID Cases	Coinfection PWH had PJP
Charifi, Y. ⁵⁷	1 PWH	Morocco	15-May-21	Clin Case Rep	Coinfecting PWH had pneumocystis with typical lesions
Massarva, T. ¹²⁶	730 PWH	Cyprus	17-May-21	Epidemiol Health	Coinfecting PWH had comparable clinical outcomes with the general population
Kumar, S. ¹⁵¹	167 PWH	India	19-May-21	New Microbes New Infect	Many PWH experience fear, anxiety and depression in the COVID-19 pandemic
Venturas, J. ¹²⁵	108 PWH/276 HIV negative controls	South Africa	26-May-21	J Infect	HIV is not a risk factor for severe COVID-19 disease or mortality
Ader, F. ²¹⁰	583 patients	France	26-May-21	Clin Microbiol Infect	COVID-19 clearance and clinical status were not improved but lopinavir/ritonavir
Pujari, S. ⁶⁷	86 PWH	India	31-May-21	AIDS Res Hum Retroviruses	Coinfecting PWH had similar clinical outcomes as the general population; comorbidities are associated with more severe outcomes
Pujari, S. ⁹⁵	94 PWH	India	2-Jun-21	Immun Inflamm Dis	Long-COVID is common among PWH with moderate-severe acute COVID-19
Rocha, S.Q. ⁶³	255 PWH	Brazil	4-Jun-21	AIDS Care	Skin color/race, and schooling remained significantly associated with higher COVID-19 mortality in PWH
Chanda, D. ¹⁰¹	122 PWH	Zambia	4-Jun-21	MMWR	Severe HIV is associated with increased risk of COVID-19 death
Di Castelnuovo, A. ²¹³	3,451 patients	Italy	9-Jun-21	Front med	DRV/c was associated with increased mortality
Wu, M. ⁵⁶	68 PWH/980 HIV negative controls	China	9-Jun-21	Res Sq	Older age was considered a driving force for coinfection in PWH

(Continued)

First author	Population	Location	Publication date	Journal	Description or findings
Wion, R.K. ¹⁵²	154 PWH	USA	15-Jun-21	AIDS Behav	PWH experienced an increase in social isolation, depression, and stress
Flannery, S. ⁹⁹	99 PWH	USA	22-Jun-21	Int J STD AIDS	Hospitalized coinfecting PWH did not have worse outcomes than the general population; PWH who had CD4% <14 or not on treatment for HIV had higher mortality rates
Berenguer, J. ²⁰³	91 PWH	Spain	26-Jun-21	Clin Microbiol Infect	TDF/FTC may prevent SARS-CoV-2 infection among PWH
Dong, Y. ⁹³	41,113 PWH/ 18,081,257 HIV negative controls	China	2-Jul-21	Medicine (Baltimore)	PWH had a higher risk of mortality from COVID-19 than those without HIV infection
Bertagnolio, S. ⁹²	15,522 PWH/ 168,649 negative controls	24 countries	15-Jul-21	WHO	PWH were at increased risk for severe or critical COVID-19

Abbreviations: PWH, person(s) living with HIV; ART, antiretroviral therapy; USA: United States of America.

comorbidities were not.⁶³ To the best of our knowledge, thus far only one study has investigated the risk of post-acute symptoms following COVID-19 and found that moderate to severe disease was associated with an increased risk of persistent symptoms in PWH.⁹⁵

Dandachi et al. ($n = 286$) noted that patients with lower CD4 counts (<200 cells/mm³) may be at risk for more severe outcomes despite viral suppression and this was supported by other smaller studies.^{20,72,84,96–103} The results of Dandachi et al. are strong and generalizable as they pull data from 36 institutions across 21 states and three countries. However, the study did not collect data on social determinants of health or COVID-19 therapies, which may have differed and confounded the results. Greater comorbidity burden in PWH has also been associated with more severe COVID-19 outcomes.^{20,28,46,64,76,77,104}

Other studies suggest that PWH have fewer COVID-19 complications, fewer admissions to the ICU, and lower mortality rates (as seen in Table 1).^{105–111} Larger cohorts from Spain, Italy, and the USA as well as many smaller studies have found no association or an unclear association between severity of outcomes such as ICU admission, need for mechanical ventilation, or mortality rates and HIV serostatus.^{34,38,44,61,74,80,99,112–147}

In general, PWH appear to be at higher risk for severe COVID-19 outcomes even after considering demographic factors and comorbidities associated with severe disease. However, it is important to note that due to the quickly changing testing procedures and requirements for hospitalization throughout the pandemic, as well as the reliance on public health

surveillance data and/or medical record review, the ability to truly distinguish severity of outcomes in PWH is difficult and often confounded.¹⁴⁸ Regardless, preventive measures for PWH should be strongly encouraged (particularly vaccination) to limit disease severity.

How does COVID-19 impact the mental health of PWH?

The social distancing and quarantine strategies required to reduce the spread of SARS-CoV-2 have left many feeling isolated and lonely. This is especially impactful to PWH as they have increased worry about physical health (68%), mental health (66%), finances (50%), and accommodation (25%) during the COVID-19 pandemic.¹⁴⁹ One study found that of 703 PWH, 61% of PWH reported depressive symptoms, 50% noted anxiety symptoms, and 39% experienced recent insomnia.¹⁵⁰ Other smaller studies have also found increased rates of depression, anxiety, insomnia, and substance abuse in relation to the COVID-19 pandemic.^{151–162} Importantly, these rates are lower amongst people who report strong levels of social support in a large study from two countries.¹⁶³

How does COVID-19 impact access to care for PWH?

The COVID-19 pandemic has restricted access to care for much of the population by restricting public transportation, suspending routine appointments, and adding financial hardships. PWH specifically are at high risk of treatment interruption due to reduced access to HIV clinics, reduction in primary care or specialty referrals, and difficulties refilling ART prescriptions.^{150,156,157,164–176} Telemedicine has proven to be

very effective in many countries as it provides flexibility in scheduling appointments, reduces the need for transportation, and provides privacy for patients not wanting to be seen attending an HIV clinic.^{149,177–184}

However, telemedicine also presents barriers including technological challenges, client/provider experiences, digital literacy, low socio-economic status of client population, and reimbursement issues.^{185–187} Many countries have identified this imbalance in access to care both with HIV diagnosis and ongoing care and have provided at-home testing kits, distributed condoms with COVID-19 testing services, and mailed ART to ensure continuity of care.^{188–193}

How does ART influence acquisition of SARS-CoV-2 or severity of COVID-19?

In the USA, an estimated 61.5% of the 1.2 million persons living with HIV are virologically suppressed using ART.¹⁹⁴ Consequently, most PWH who develop COVID-19 will be on suppressive ART. While maintaining suppressed viral load and a normal CD4 T-lymphocyte count likely decreases the risk of severe COVID-19, there is yet to be clear evidence that ART itself prevents the acquisition of SARS-CoV-2 infection or alters the rate of progression to severe disease.^{51,144,195–201} Three observational studies have suggested a potential protective role of tenofovir disoproxil fumarate (TDF)/emtricitabine (FTC) among PWH.^{91,202,203} The last of these adjusted for comorbidities, demographics, country of birth, and education level. As TDF/FTC tends to be avoided due to toxicity among older patients with more comorbid conditions, this finding may be due to confounders of younger age and fewer comorbidities, rather than a protective effect of the drug.^{91,202} Similarly, the HIV protease inhibitor lopinavir-ritonavir has in vitro activity against SARS-CoV-2 and some speculate that it may be protective against COVID-19.²⁰⁴ However, a randomized control trial of this medication in 199 HIV-negative persons with COVID-19 have failed to demonstrate a clinical benefit and other studies, including systemic reviews and meta-analyses, support the conclusion that ART does not serve a protective role against SARS-CoV-2 infection.^{49,205–212} A study of darunavir/cobicistat actually showed an increased mortality rate.²¹³ However, this was an observational study that may have been affected by confounders.

General management of COVID-19 among PWH

The guidelines for management of care for PWH and COVID-19 does not differ from those without HIV, although the likelihood of severe disease and poor

outcomes may be heightened. Thus, we suggest that the following principles of HIV management are important in persons who present with COVID-19²¹⁴:

- Public health precautions including hand hygiene, mask wearing, and physical distancing should be strictly adhered to.
- Compliance with routine vaccinations, including influenza, should be emphasized.
- COVID-19 vaccination should be given.
- Consideration could be given to telehealth visits in place of in-person visits to ensure continuity of care, particularly in areas of high COVID-19 rates and when there are no acute health concerns.
- For persons who are on HIV treatment, ART and opportunistic infection prophylaxis (if applicable) should be continued, if feasible based on the patient's clinical condition.
- ART should not be adjusted in an attempt to treat COVID-19.
- With regards to COVID-19 treatment, there are no significant drug–drug interactions between remdesivir and ART. Dexamethasone is an inducer of hepatic metabolism of drugs and could decrease the levels of some co-administered ART.²¹⁵ As the course of dexamethasone is typically limited to 10 days or less, it is unlikely that this interaction will be significant in most circumstances.
- If there is a need to adjust or change ART, consultation with an HIV specialist is recommended. For critically ill patients who require enteral feeding, some ART are available in liquid formulations and some pills may be crushed. Clinicians should consult an HIV specialist and/or pharmacist to assess the best way for a patient with a feeding tube to continue an effective regimen.
- Regarding prophylaxis for opportunistic infections, whether the lymphopenia associated with COVID-19 places PWH at higher risk for opportunistic infections is not currently known. As this lymphopenia is limited, the risk of acquiring infections is not expected to alter prophylactic therapy.
- As COVID-19 may occur more commonly in people with limited prior access or engagement to the health-care system, the hospitalization is an opportunity to screen for HIV and other infections (hepatitis C, tuberculosis), as indicated. For persons who present with COVID-19 and a new diagnosis of HIV infection, the timing of starting ART is currently unknown. Currently, the Department of Health and Human Services guidelines recommend immediate initiation of ART in persons with newly diagnosed HIV infection.²¹⁴ Immune reconstitution could help in the management of SARS-CoV-2 infection. In contrast, immune reconstitution could also exacerbate the inflammatory response and worsen respiratory failure or contribute to a hypercoagulable state in others. Other characteristics such as renal failure, thrombosis, or mechanical ventilation might suggest a delay in ART initiation to avoid further exacerbating inflammation. Consultation with an HIV specialist is advised.

Conclusion

Although initial case studies and small cohorts found similar rates of infection and severity in PWH, the growing literature in diverse settings throughout the course of the pandemic now suggests that PWH are at greater risk for severe disease, even with well-controlled HIV. As the pandemic continues, PWH should be counseled regarding the heightened risk from HIV, in addition to other demographic or comorbid factors. Precautions to limit unnecessary exposure and decrease risk for acquisition (i.e. handwashing, physical distancing, mask wearing) should be encouraged particularly during surges in infection rates. While the general care of PWH who also acquire SARS-CoV-2 infection does not differ from people without HIV, certain considerations regarding drug–drug interactions can be guided through consultation with an HIV specialist. Lastly, while separate from the direct complications of COVID-19, the isolation and loneliness experienced during this pandemic, potential interruptions of medication therapy, and reduced access to care may have an even more profound effect on those experiencing the stigma of HIV. Ensuring that PWH are able to stay connected to local resources and monitoring for the impact on mental health and well-being will have important long-term implications.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported in part by the National Institutes of Health, National Institute on Aging [R01AG054366-05S] and the GEMS-Health Professionals Program [R25HL103286]. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. KME has received grant funding from Gilead Sciences (paid to the University of Colorado).

Notes on contributors

Lauren K. Barbera is an MD candidate at the University of Colorado School of Medicine in Aurora, CO.

Kevin F. Kamis, MPH, is a Researcher at Denver Public Health, a department within Denver Health and Hospital Authority, Denver, CO, USA.

Sarah E. Rowan, MD, is an Associate Professor in the Division of Infectious Diseases at the University of Colorado Denver and the Associate Director of

HIV and Viral Hepatitis Prevention at Denver Public Health, a division of Denver Health and Hospital Authority.

Amelia J. Davis is a MD/MPH candidate at the University of Colorado School of Medicine and the Colorado School of Public Health in Aurora, CO.

Soraya Shehata is a MD/PhD candidate at the University of Colorado School of Medicine, currently completing her thesis work in the Molecular, Cellular, and Developmental Biology Department of CU Boulder.

Jesse J. Carlson is a Research Associate at Denver Public Health and an MPH candidate at the Colorado School of Public Health in Aurora, CO.

Steven C. Johnson, MD, is a Professor of Medicine and the Associate Division Head for Clinical Affairs in the Division of Infectious Diseases, Department of Medicine, at the University of Colorado School of Medicine in Aurora, Colorado.

Kristine M. Erlandson, MD, MS is an Associate Professor of Medicine and Epidemiology at the University of Colorado in Aurora, CO.

References

- 1 Fung M, Babik JM. COVID-19 in immunocompromised hosts: what we know so far. *Clin Infect Dis*. 2021;72(2):340–350.
- 2 Maartens G, Boule A. CD4 T-cell responses to combination antiretroviral therapy. *Lancet*. 2007;370(9585):366–368.
- 3 Marcus JL, Baxter R, Leyden WA, et al. Invasive pneumococcal disease among HIV-infected and HIV-uninfected adults in a large integrated healthcare system. *AIDS Patient Care STDS*. 2016;30(10):463–470.
- 4 Folaranmi TA, Kretz CB, Kamiya H, et al. Increased risk for meningococcal disease among men who have sex with men in the United States, 2012–2015. *Clin Infect Dis*. 2017;65(8):756–763.
- 5 Patel P, Bush T, Mayer KH, et al. Prevalence and risk factors associated with herpes simplex virus-2 infection in a contemporary cohort of HIV-infected persons in the United States. *Sex Transm Dis*. 2012;39(2):154–160.
- 6 Barrera-López P, Pérez-Riveros ED, Moreno-Montoya J, Ballesteros SM, Valencia SA, De la Hoz-Valle JA. Co-infection of other respiratory pathogens and HIV in COVID-19 patients: is there a pattern? *J Med Virol*. 2021;93(1):8–19.
- 7 Larzábal FJ, Vilela A, Brusca S, Saluzzi I, Ghergo GE, Angiono MA. Simultaneous diagnosis and favorable evolution of infection with *Pneumocystis jirovecii*, SARS-CoV-2 and advanced HIV. *Medicina (B Aires)*. 2020;80(5):554–556.
- 8 Lau J, Knudsen J, Jackson H, et al. Staying connected in the COVID-19 pandemic: telehealth at the largest safety-net system in the United States. *Health Aff (Millwood)*. 2020;39(8):1437–1442.
- 9 Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus disease 2019 case surveillance – United States, January 22–May 30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(24):759–765.
- 10 Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *Jama*. 2020;323(20):2052–2059.
- 11 Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N Engl J Med*. 2020;382(26):2534–2543.

- 12 Lighter J, Phillips M, Hochman S, et al. Obesity in patients younger than 60 years is a risk factor for COVID-19 hospital admission. *Clin Infect Dis*. 2020;71(15):896–897.
- 13 Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020;395(10229):1054–1062.
- 14 Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: prospective cohort study. *BMJ*. 2020;369:m1966.
- 15 CDC. HIV Surveillance Report: Supplemental Report. Estimated HIV incidence and prevalence in the United States, 2014–2018. Centers for Disease Control and Prevention. <http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html>. Published 2020. Accessed 1, 25.
- 16 Erlandson KM, Karris MY. HIV and aging: reconsidering the approach to management of comorbidities. *Infect Dis Clin North Am*. 2019;33(3):769–786.
- 17 Schouten J, Wit FW, Stolte IG, et al. Cross-sectional comparison of the prevalence of age-associated comorbidities and their risk factors between HIV-infected and uninfected individuals: the AGEHIV cohort study. *Clin Infect Dis*. 2014;59(12):1787–1797.
- 18 Fields EL, Copeland R, Hopkins E. Same script, different viruses: HIV and COVID-19 in US Black communities. *Lancet*. 2021;397(10279):1040–1042.
- 19 Bhaskaran K, Rentsch CT, MacKenna B, et al. HIV infection and COVID-19 death: a population-based cohort analysis of UK primary care data and linked national death registrations within the OpenSAFELY platform. *Lancet HIV*. 2021;8(1):e24–e32.
- 20 Dandachi D, Geiger G, Montgomery MW, et al. Characteristics, comorbidities, and outcomes in a multicenter registry of patients with HIV and coronavirus disease-19 [published ahead of print]. *Clin Infect Dis*. 2020. <https://doi.org/10.1093/cid/ciaa1339>
- 21 Weiser JK, Tie Y, Beer L, Fanfair RN, Shouse RL. Racial/ethnic and income disparities in the prevalence of comorbidities that are associated with risk for severe COVID-19 among adults receiving HIV care, United States. *J Acquir Immune Defic Syndr*. 2020;86(3):297–304.
- 22 Patel RH, Acharya A, Chand HS, Mohan M, Byrareddy SN. Human immunodeficiency virus and severe acute respiratory syndrome coronavirus 2 coinfection: a systematic review of the literature and challenges. *AIDS Res Hum Retroviruses*. 2021;37(4):266–282.
- 23 Altuntas Aydin O, Kumbasar Karaosmanoglu H, Kart Yasar K. HIV/SARS-CoV-2 coinfecting patients in Istanbul, Turkey. *J Med Virol*. 2020;92(11):2288–2290.
- 24 Hattab S, Guiguet M, Carcelain G, et al. Soluble biomarkers of immune activation and inflammation in HIV infection: impact of 2 years of effective first-line combination antiretroviral therapy. *HIV Med*. 2015;16(9):553–562.
- 25 Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497–506.
- 26 Zhu F, Cao Y, Xu S, Zhou M. Co-infection of SARS-CoV-2 and HIV in a patient in Wuhan city, China. *J Med Virol*. 2020;92(6):529–530.
- 27 Suwanwongse K, Shabarek N. Clinical features and outcome of HIV/SARS-CoV-2 coinfecting patients in The Bronx, New York City. *J Med Virol*. 2020;92(11):2387–2389.
- 28 Hadi YB, Naqvi SFZ, Kupec JT, Sarwari AR. Characteristics and outcomes of COVID-19 in patients with HIV: a multi-center research network study. *Aids*. 2020;34(13):F3–F8.
- 29 Chenneville T, Gabbidon K, Hanson P, Holyfield C. The impact of COVID-19 on HIV treatment and research: a call to action. *Int J Environ Res Public Health*. 2020;17(12):4548.
- 30 Laurence J. Why aren't people living with HIV at higher risk for developing severe coronavirus disease 2019 (COVID-19)? *AIDS Patient Care STDS*. 2020;34(6):247–248.
- 31 d'Ettorre G, Recchia G, Ridolfi M, et al. Analysis of type I IFN response and T cell activation in severe COVID-19/HIV-1 coinfection: a case report. *Medicine (Baltimore)*. 2020;99(36):e21803.
- 32 Zhang JC, Yu XH, Ding XH, et al. New HIV diagnoses in patients with COVID-19: two case reports and a brief literature review. *BMC Infect Dis*. 2020;20(1):771.
- 33 Blanco JL, Ambrosioni J, Garcia F, et al. COVID-19 in patients with HIV: clinical case series. *Lancet HIV*. 2020;7(5):e314–e316.
- 34 Huang J, Xie N, Hu X, et al. Epidemiological, virological and serological features of COVID-19 cases in people living with HIV in Wuhan City: a population-based cohort study [published ahead of print]. *Clin Infect Dis*. 2020. <https://doi.org/10.1093/cid/ciaa1186>
- 35 Shalev N, Scherer M, LaSota ED, et al. Clinical characteristics and outcomes in people living with HIV hospitalized for COVID-19. *Clin Infect Dis*. 2020;71(16):2294–2297.
- 36 WHO. Global Health Observatory (GHO) Data. who.int/gho/hiv/en. Published 2020. Accessed October 3, 2020.
- 37 Inciarte A, Gonzalez-Cordon A, Rojas J, et al. Clinical characteristics, risk factors, and incidence of symptomatic coronavirus disease 2019 in a large cohort of adults living with HIV: a single-center, prospective observational study. *AIDS*. 2020;34(12):1775–1780.
- 38 Vizcarra P, Pérez-Elías MJ, Quereda C, et al. Description of COVID-19 in HIV-infected individuals: a single-centre, prospective cohort. *Lancet HIV*. 2020;7(8):e554–e564.
- 39 Charre C, Icard V, Pradat P, et al. COVID-19 attack rate in HIV-infected patients and in PrEP users. *AIDS*. 2020;34(12):1765–1770.
- 40 de Medeiros KS, Silva LAS d, Macêdo LTA, et al. Potential impact of the COVID-19 in HIV-infected individuals: a systematic review. Impact of the COVID-19 in HIV-infected individuals. *Rev Assoc Med Bras (1992)*. 2021;67(Suppl 1):127–156.
- 41 Ridgway JP, Schmitt J, Friedman E, et al. HIV care continuum and COVID-19 outcomes among people living with HIV during the COVID-19 pandemic, Chicago, IL. *AIDS Behav*. 2020;24(10):2770–2772.
- 42 Sachdev D, Mara E, Hsu L, et al. COVID-19 susceptibility and outcomes among people living with HIV in San Francisco. *J Acquir Immune Defic Syndr*. 2021;86(1):19–21.
- 43 CDC. What to Know about HIV and COVID-19. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/hiv.html>. Published 2020. Accessed October 1, 2020.
- 44 Park LS, Rentsch CT, Sigel K, et al. COVID-19 in the Largest US HIV Cohort. Paper presented at: AIDS 2020: 23rd International AIDS Conference 2020; Virtual.
- 45 Fusco FM, Sangiovanni V, Tiberio C, Papa N, Atripaldi L, Esposito V. Persons living with HIV may be reluctant to access to COVID-19 testing services: data from 'D. Cotugno' Hospital, Naples, Southern Italy. *AIDS*. 2020;34(14):2151–2152.
- 46 Collins LF, Moran CA, Oliver NT, et al. Clinical characteristics, comorbidities and outcomes among persons with HIV hospitalized with coronavirus disease 2019 in Atlanta, Georgia. *AIDS*. 2020;34(12):1789–1794.
- 47 Härter G, Spinner CD, Roeder J, et al. COVID-19 in people living with human immunodeficiency virus: a case series of 33 patients. *Infection*. 2020;48(5):681–686.
- 48 Calza L, Bon I, Tadolini M, et al. COVID-19 in patients with HIV-1 infection: a single-centre experience in northern Italy. *Infection*. 2021;49(2):333–335.
- 49 Childs K, Post FA, Norcross C, et al. Hospitalized patients with COVID-19 and human immunodeficiency virus: a case series. *Clin Infect Dis*. 2020;71(8):2021–2022.
- 50 Ridgway JP, Farley B, Benoit JL, et al. A case series of five people living with HIV hospitalized with COVID-19 in Chicago, Illinois. *AIDS Patient Care STDS*. 2020;34(8):331–335.
- 51 Gatechompol S, Avihingsanon A, Puthachoen O, Ruxrungtham K, Kuritzkes DR. COVID-19 and HIV infection co-pandemics and their impact: a review of the literature. *AIDS Res Ther*. 2021;18(1):28.
- 52 Su J, Shen X, Ni Q, et al. Infection of severe acute respiratory syndrome coronavirus 2 in a patient with AIDS. *AIDS*. 2020;34(10):1575–1576.
- 53 D'Souza G, Springer G, Gustafson D, et al. COVID-19 symptoms and SARS-CoV-2 infection among people living with

- HIV in the US: the MACS/WIHS combined cohort study. *HIV Res Clin Pract.* 2020;21(5):130–110.
- 54 Bertolini M, Mutti MF, Barletta JA, et al. COVID-19 associated with AIDS-related disseminated histoplasmosis: a case report. *Int J STD AIDS.* 2020;31(12):1222–1224.
- 55 Coleman H, Snell LB, Simons R, Douthwaite ST, Lee MJ. Coronavirus disease 2019 and *Pneumocystis jirovecii* pneumonia: a diagnostic dilemma in HIV. *AIDS.* 2020;34(8):1258–1260.
- 56 Wu M, Ming F, Wu S, et al. Distinct infection forms of SARS-CoV-2 among people living with HIV [published ahead of print]. *Res Sq.* 2021. <https://doi.org/10.21203/rs.3.rs-569883/v1>
- 57 Charifi Y, Rabhi S, Sekkat G, et al. Unusual imaging findings of SARS-CoV-2 in HIV-positive patient: a case report. *Clin Case Rep.* 2021;9(5):e04004.
- 58 Merchant EA, Flint K, Barouch DH, Blair BM. Co-infection with coronavirus disease 2019, previously undiagnosed human immunodeficiency virus, *Pneumocystis jirovecii* pneumonia and cytomegalovirus pneumonitis, with possible immune reconstitution inflammatory syndrome. *IDCases.* 2021;24:e01153.
- 59 Farinacci D, Ciccullo A, Borghetti A, et al. People living with HIV in the COVID-19 era: a case report. *AIDS Res Hum Retroviruses.* 2021;37(4):253–254.
- 60 Mang S, Kaddu-Mulindwa D, Metz C, et al. *Pneumocystis jirovecii* pneumonia and severe acute respiratory syndrome coronavirus 2 coinfection in a patient with newly diagnosed HIV-1 infection. *Clin Infect Dis.* 2021;72(8):1487–1489.
- 61 Maggiolo F, Zoboli F, Arosio M, et al. SARS-CoV-2 infection in persons living with HIV: a single center prospective cohort. *J Med Virol.* 2021;93(2):1145–1149.
- 62 Kaswa R, Yogeswaran P, Cawe B. Clinical outcomes of hospitalised COVID-19 patients at Mthatha Regional Hospital, Eastern Cape, South Africa: a retrospective study. *S Afr Fam Pract (2004).* 2021;63(1):e1–e5.
- 63 Rocha SQ, Avelino-Silva VI, Tancredi MV, et al. COVID-19 and HIV/AIDS in a cohort study in Sao Paulo, Brazil: outcomes and disparities by race and schooling [published ahead of print]. *AIDS Care.* 2021. <https://doi.org/10.1080/09540121.2021.1936444>
- 64 Etienne N, Karmochkine M, Slama L, et al. HIV infection and COVID-19: risk factors for severe disease. *AIDS.* 2020;34(12):1771–1774.
- 65 Nasreddine R, Florence E, Moutschen M, et al. Clinical characteristics and outcomes of COVID-19 in people living with HIV in Belgium: a multicenter, retrospective cohort. *J Med Virol.* 2021;93(5):2971–2978.
- 66 Robles-Pérez E, González-Díaz B, Miranda-García M, Borja-Aburto VH. Infection and death by COVID-19 in a cohort of healthcare workers in Mexico. *Scand J Work Environ Health.* 2021;47(5):349–355.
- 67 Pujari S, Gaikwad S, Chitalikar A, Dabhade D, Joshi K, Bele V. Coronavirus disease 19 among people living with HIV in Western India: an observational cohort study. *AIDS Res Hum Retroviruses.* 2021;37(8):620–623.
- 68 Maggi P, Ricci E, Messina V, et al. Dangerous liaisons? The role of inflammation and comorbidities in HIV and SARS-CoV-2 infection. *Expert Rev Clin Immunol.* 2021;17(3):201–208.
- 69 Morani Z, Patel S, Ghosh S, et al. COVID-19 in HIV: a review of published case reports. *SN Compr Clin Med.* 2020;2:2647–2657.
- 70 Sasset L, Di Meco E, Cavinato S, Cattelan AM. Coinfection of severe acute respiratory syndrome coronavirus 2 and HIV in a teaching hospital: still much to learn. *AIDS.* 2020;34(11):1694–1696.
- 71 Mirzaei H, McFarland W, Karamouzian M, Sharifi H. COVID-19 among people living with HIV: a systematic review. *AIDS Behav.* 2021;25(1):85–88.
- 72 Ambrosioni J, Blanco JL, Reyes-Uruña JM, et al. Overview of SARS-CoV-2 infection in adults living with HIV. *Lancet HIV.* 2021;8(5):e294–e305.
- 73 Docherty AB, Harrison EM, Green CA, et al. Features of 20 133 UK patients in hospital with covid-19 using the ISARIC WHO clinical characterisation protocol: prospective observational cohort study. *BMJ.* 2020;369:m1985.
- 74 Sigel K, Swartz T, Golden E, et al. Covid-19 and people with HIV infection: outcomes for hospitalized patients in New York City. *Clin Infect Dis.* 2020;71(11):2933–2938.
- 75 Meyerowitz EA, Kim AY, Ard KL, et al. Disproportionate burden of COVID-19 among racial minorities and those in congregate settings among a large cohort of people with HIV. *AIDS.* 2020;34(12):1781–1787.
- 76 Guo W, Ming F, Feng Y, et al. Patterns of HIV and SARS-CoV-2 co-infection in Wuhan, China. *J Int AIDS Soc.* 2020;23(7):e25568.
- 77 Winston A, De Francesco D, Post F, et al. Comorbidity indices in people with HIV and considerations for coronavirus disease 2019 outcomes. *AIDS.* 2020;34(12):1795–1800.
- 78 Isernia V, Julia Z, Le Gac S, et al. SARS-COV2 infection in 30 HIV-infected patients followed-up in a French University Hospital. *Int J Infect Dis.* 2020;101:49–51.
- 79 Miró JM, Ambrosioni J, Blanco JL. COVID-19 in patients with HIV – Authors' reply. *Lancet HIV.* 2020;7(6):e383–e384.
- 80 Karmen-Tuohy S, Carlucci PM, Zervou FN, et al. Outcomes among HIV-positive patients hospitalized with COVID-19. *J Acquir Immune Defic Syndr.* 2020;85(1):6–10.
- 81 Iordanou S, Koukios D, Matsentidou-Timiliotou C, Markoulaki D, Rafopoulou V. Severe SARS-CoV-2 pneumonia in a 58-year-old patient with HIV: a clinical case report from the Republic of Cyprus. *J Med Virol.* 2020;92(11):2361–2365.
- 82 Wang M, Luo L, Bu H, Xia H. One case of coronavirus disease 2019 (COVID-19) in a patient co-infected by HIV with a low CD4+ T-cell count. *Int J Infect Dis.* 2020;96:148–150.
- 83 Chiappe Gonzalez AJ, Montenegro-Idrogo JJ, Vargas Vadillo AR, Sleg Torres M, Vargas Matos I, Resurrección Delgado CP. Hospital-acquired SARS-CoV-2 pneumonia in a person living with HIV. *Int J STD AIDS.* 2020;31(13):1320–1322.
- 84 Ho H-E, Peluso MJ, Margus C, et al. Clinical outcomes and immunologic characteristics of coronavirus disease 2019 in people with human immunodeficiency virus. *J Infect Dis.* 2021;223(3):403–408.
- 85 Geretti AM, Stockdale A, Kelly S, et al. Outcomes of COVID-19 related hospitalisation among people with HIV in the ISARIC WHO Clinical Characterisation Protocol (UK): prospective observational study [published ahead of print]. *Clin Infect Dis.* 2020. <https://doi.org/10.1093/cid/ciaa1605>
- 86 Prabhu S, Poongulali S, Kumarasamy N. Impact of COVID-19 on people living with HIV: a review. *J Virus Erad.* 2020;6(4):100019.
- 87 Spinelli MA, Lynch KL, Yun C, et al. SARS-CoV-2 seroprevalence, and IgG concentration and pseudovirus neutralising antibody titres after infection, compared by HIV status: a matched case-control observational study. *Lancet HIV.* 2021;8(6):e334–e341.
- 88 Ssentongo P, Heilbrunn ES, Ssentongo AE, et al. Epidemiology and outcomes of COVID-19 in HIV-infected individuals: a systematic review and meta-analysis. *Sci Rep.* 2021;11(1):6283.
- 89 Tesoriero JM, Swain CE, Pierce JL, et al. COVID-19 outcomes among persons living with or without diagnosed HIV infection in New York State. *JAMA Netw Open.* 2021;4(2):e2037069.
- 90 Tesoriero JM, Swain CE, Pierce JL, et al. Elevated COVID-19 outcomes among persons living with diagnosed HIV infection in New York State: results from a population-level match of HIV, COVID-19, and hospitalization databases [online]. *medRxiv.* 2020.
- 91 Boule A, Davies MA, Hussey H, et al. Risk factors for COVID-19 death in a population cohort study from the Western Cape Province, South Africa [published ahead of print]. *Clin Infect Dis.* 2020. <https://doi.org/10.1093/cid/ciaa1198>
- 92 Bertagnolio S, Thwin SS, Silva R, Clinical DJ. Features and prognostic factors of COVID-19 in people living with HIV hospitalized with suspected or confirmed SARS-CoV-2 infection. WHO 2021(20).
- 93 Dong Y, Li Z, Ding S, et al. HIV infection and risk of COVID-19 mortality: a meta-analysis. *Medicine (Baltimore).* 2021;100(26):e26573.
- 94 Hariyanto TI, Rosalind J, Christian K, Kurniawan A. Human immunodeficiency virus and mortality from coronavirus disease 2019: a systematic review and meta-analysis. *South Afr J HIV Med.* 2021;22(1):1220.

- 95 Pujari S, Gaikwad S, Chitalikar A, Dabhade D, Joshi K, Bele V. Long-coronavirus disease among people living with HIV in western India: an observational study. *Immun Inflamm Dis*. 2021;9(3):1037–1043.
- 96 Di Biagio A, Ricci E, Calza L, et al. Factors associated with hospital admission for COVID-19 in HIV patients. *AIDS*. 2020; 34(13):1983–1985.
- 97 Yang R, Gui X, Zhang Y, Xiong Y, Gao S, Ke H. Clinical characteristics of COVID-19 patients with HIV coinfection in Wuhan, China. *Expert Rev Respir Med*. 2021;15(3):403–409.
- 98 Turken M, Altan H, Atalay S, Kose S. The course of COVID-19 in four patients with HIV during the pandemic. *Curr HIV Res*. 2020;19:286–291.
- 99 Flannery S, Schwartz R, Rasul R, et al. A comparison of COVID-19 inpatients by HIV status [published ahead of print]. *Int J STD AIDS*. 2021. <https://doi.org/10.1177/09564624211023015>
- 100 Goldman JD, Robinson PC, Uldrick TS, Ljungman P. COVID-19 in immunocompromised populations: implications for prognosis and repurposing of immunotherapies. *J Immunother Cancer*. 2021;9(6).
- 101 Chanda D, Minchella PA, Kampamba D, et al. COVID-19 severity and COVID-19-associated deaths among hospitalized patients with HIV infection – Zambia, March–December 2020. *MMWR Morb Mortal Wkly Rep*. 2021;70(22):807–810.
- 102 Ruan L, Zhang Y, Luo Y, et al. Clinical features and outcomes of four HIV patients with COVID-19 in Wuhan, China. *J Med Virol*. 2021;93(1):133–136.
- 103 Braunstein SL, Lazar R, Wahnich A, Daskalakis DC, Blackstock OJ. COVID-19 infection among people with HIV in New York City: a population-level analysis of linked surveillance data. *Clin Infect Dis*. 2021;72(12):e1021–e1029.
- 104 Liang M, Luo N, Chen M, et al. Prevalence and mortality due to COVID-19 in HIV co-infected population: a systematic review and meta-analysis. *Infect Dis Ther*. 2021;10(3):1267–1219.
- 105 Gervasoni C, Meraviglia P, Riva A, et al. Clinical features and outcomes of HIV patients with coronavirus disease 2019. *Clin Infect Dis*. 2020;71(16):2276–2278.
- 106 Patel RH, Pella PM. COVID-19 in a patient with HIV infection. *J Med Virol*. 2020;92(11):2356–2357.
- 107 Patel RH, Acharya A, Mohan M, Byrareddy SN. COVID-19 and AIDS: outcomes from the coexistence of two global pandemics and the importance of chronic antiretroviral therapy. *J Med Virol*. 2021;93(2):641–643.
- 108 Tian C, Tang L, Wu J, et al. An HIV-infected patient with coronavirus disease 2019 has a favourable prognosis: a case report. *Ann Palliat Med*. 2021;10(5):5808–5812.
- 109 Qasim A, Mansour M, Kousa O, et al. A case of coronavirus disease 2019 in acquired immunodeficiency syndrome patient: a case report and review of the literature. *Intractable Rare Dis Res*. 2020;9(4):256–259.
- 110 Shekhar R, Barton A, Sheikh AB, Upadhyay S, Salas NM. Coronavirus disease of 2019 in patients with well-controlled human immunodeficiency virus on antiretroviral therapy. *J Acquir Immune Defic Syndr*. 2020;85(1):e1–e4.
- 111 Sun LJ, Wong SXL, Gollamudi S. A case of HIV and SARS-CoV-2 co-infection in Singapore. *J Acquir Immune Defic Syndr*. 2020;84(4):e23–e24.
- 112 Gudipati S, Brar I, Murray S, McKinnon JE, Yared N, Markowitz N. Descriptive analysis of patients living with HIV affected by COVID-19. *J Acquir Immune Defic Syndr*. 2020; 85(2):123–126.
- 113 Benkovic S, Kim M, Sin E. Four cases: human immunodeficiency virus and novel coronavirus 2019 co-infection in patients from Long Island, New York. *J Med Virol*. 2020;92(11): 2338–2340.
- 114 Nagarakanti SR, Okoh AK, Grinberg S, Bishburg E. Clinical outcomes of patients with COVID-19 and HIV coinfection. *J Med Virol*. 2021;93(3):1687–1693.
- 115 Byrd KM, Beckwith CG, Garland JM, et al. SARS-CoV-2 and HIV coinfection: clinical experience from Rhode Island, United States. *J Int AIDS Soc*. 2020;23(7):e25573.
- 116 Stoeckle K, Johnston CD, Jannat-Khah DP, et al. COVID-19 in hospitalized adults with HIV. *Open Forum Infect Dis*. 2020; 7(8):ofaa327.
- 117 Madge S, Barber TJ, Hunter A, Bhagani S, Lipman M, Burns F. Descriptive account of 18 adults with known HIV infection hospitalised with SARS-CoV-2 infection. *Sex Transm Infect*. 2021;97(5):392–393.
- 118 Kim JY, Kim JM, Peck KR. The first case of an HIV patient diagnosed with COVID-19 in Korea. *J Korean Med Sci*. 2020; 35(39):e358.
- 119 Cajamarca-Baron J, Guavita-Navarro D, Buitrago-Bohorquez J, et al. SARS-CoV-2 (COVID-19) in patients with some degree of immunosuppression. *Reumatol Clin*. 2021;17:408–419.
- 120 Mondì A, Cimini E, Colavita F, et al. COVID-19 in people living with HIV: clinical implications of dynamics of the immune response to SARS-CoV-2. *J Med Virol*. 2021;93(3):1796–1804.
- 121 Sarkar S, Khanna P, Singh AK. Impact of COVID-19 in patients with concurrent co-infections: a systematic review and meta-analyses. *J Med Virol*. 2021;93(4):2385–2395.
- 122 Kowalska JD, Kase K, Vassilenko A, et al. The characteristics of HIV-positive patients with mild/asymptomatic and moderate/severe course of COVID-19 disease – a report from Central and Eastern Europe. *Int J Infect Dis*. 2021;104:293–296.
- 123 Gamboa E, Duran M, Gathe JC, Jr., Surani S, Varon J. COVID-19 coexisting with the human immunodeficiency virus: a case report. *Cureus*. 2020;12(10):e11007.
- 124 Eybpoosh S, Afshari M, Haghdoost AAA, Kazerooni P, Gouya MM, Tayeri K. Severity and mortality of COVID-19 infection in HIV-infected individuals: preliminary findings from Iran. *Med J Islam Repub Iran*. 2021;35:33.
- 125 Venturas J, Zamparini J, Shaddock E, et al. Comparison of outcomes in HIV-positive and HIV-negative patients with COVID-19. *J Infect*. 2021;83(2):217–227.
- 126 Massarvva T. Clinical outcomes of COVID-19 amongst HIV patients: a systematic literature review. *Epidemiol Health*. 2021; 43:e2021036.
- 127 Hardy YO, Amenuke DA, Hutton-Mensah KA, Chadwick DR, Larsen-Reindorf R. Presentation and outcome of COVID-19 in HIV patients with high viral loads and opportunistic infections: a case series. *Ghana Med J*. 2020;54(4 Suppl):121–124.
- 128 Durstenfeld MS, Sun K, Ma Y, et al. Impact of HIV infection on COVID-19 outcomes among hospitalized adults in the U.S. [online]. *medRxiv*. 2021.
- 129 Toombs JM, Van den Abbeele K, Democratis J, Merricks R, Mandal AKJ, Missouri CG. COVID-19 in three people living with HIV in the United Kingdom. *J Med Virol*. 2021;93(1): 107–109.
- 130 Mohindra R, Kanta P, Porchezian P, et al. COVID-19 infection in a HIV positive health care worker: first case report from a tertiary care hospital of North India. *Virusdisease*. 2021; 32(2):1–5.
- 131 Lee KW, Yap SF, Ngeow YF, Lye MS. COVID-19 in people living with HIV: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2021;18(7):3554.
- 132 Laracy J, Zucker J, Castor D, et al. HIV-1 infection does not change disease course or inflammatory pattern of SARS-CoV-2-infected patients presenting at a large urban medical center in New York City. *Open Forum Infect Dis*. 2021;8(2):ofab029.
- 133 Ceballos ME, Ross P, Lasso M, et al. Clinical characteristics and outcomes of people living with HIV hospitalized with COVID-19: a nationwide experience. *Int J STD AIDS*. 2021; 32(5):435–443.
- 134 Patel VV, Felsen UR, Fisher M, et al. Clinical outcomes and inflammatory markers by HIV serostatus and viral suppression in a large cohort of patients hospitalized with COVID-19. *J Acquir Immune Defic Syndr*. 2021;86(2):224–230.
- 135 Noe S, Schabaz F, Heldwein S, et al. HIV and SARS-CoV-2 co-infection: cross-sectional findings from a German 'hotspot'. *Infection*. 2021;49(2):313–320.
- 136 Parker A, Koegelenberg CFN, Moolla MS, et al. High HIV prevalence in an early cohort of hospital admissions with COVID-19 in Cape Town, South Africa. *S Afr Med J*. 2020; 110(10):982–987.
- 137 Cabello A, Zammaro B, Nistal S, et al. COVID-19 in people living with HIV: a multicenter case-series study. *Int J Infect Dis*. 2021;102:310–315.
- 138 Guo W, Ming F, Dong Y, et al. Driving force of covid-19 among people living with HIV/AIDS in Wuhan, China

- [published ahead of print]. *Res Sq.* 2020. <https://doi.org/10.21203/rs.3.rs-53351/v1>
- 139 Molina-Iturriza E, San-José-Muñiz I, Ganchegui-Aguirre M, et al. Coronavirus disease 2019 in patients with HIV in the province of Araba, Basque Country, Spain. *AIDS.* 2020;34(11):1696–1697.
 - 140 Cooper TJ, Woodward BL, Alom S, Harky A. Coronavirus disease 2019 (COVID-19) outcomes in HIV/AIDS patients: a systematic review. *HIV Med.* 2020;21(9):567–577.
 - 141 Adachi E, Saito M, Ikeuchi K, Hoshina T, Yotsuyanagi H. Cases of coronavirus disease-2019 in HIV-infected transgender women. *AIDS.* 2020;34(9):1435–1436.
 - 142 Okoh AK, Bishburg E, Grinberg S, Nagarakanti S. COVID-19 pneumonia in patients with HIV: a case series. *J Acquir Immune Defic Syndr.* 2020;85(1):e4–e5.
 - 143 Xu Z, Zhang C, Wang FS. COVID-19 in people with HIV. *Lancet HIV.* 2020;7(8):e524–e526.
 - 144 Costenaro P, Minotti C, Barbieri E, Giaquinto C, Dona D. SARS-CoV-2 infection in people living with HIV: a systematic review. *Rev Med Virol.* 2021;31(1):e2155.
 - 145 Swaminathan N, Moussa P, Mody N, Lo KB, Patarroyo-Aponte G. COVID-19 in HIV-infected patients: a case series and literature review. *J Med Virol.* 2021;93(5):2557–2563.
 - 146 Liu WD, Hung CC, Wang JT, et al. Evolution of SARS-CoV-2 neutralizing antibody in an HIV-positive patient with COVID-19 [published ahead of print]. *J Formos Med Assoc.* 2021. <https://doi.org/10.1016/j.jfma.2021.04.010>
 - 147 Kanwugu ON, Adadi P. HIV/SARS-CoV-2 coinfection: a global perspective. *J Med Virol.* 2021;93(2):726–732.
 - 148 Waters LJ, Pozniak AL. COVID-19 death in people with HIV: interpret cautiously. *Lancet HIV.* 2021;8(1):e2–e3.
 - 149 Weerasuria M, Ko C, Ehm A, et al. The impact of the COVID-19 pandemic on people living with HIV in Victoria, Australia. *AIDS Res Hum Retroviruses.* 2021;37(4):322–328.
 - 150 Sun S, Hou J, Chen Y, Lu Y, Brown L, Operario D. Challenges to HIV care and psychological health during the COVID-19 pandemic among people living with HIV in China. *AIDS Behav.* 2020;24(10):2764–2765.
 - 151 Kumar S. AIDS and COVID-19 infections: impact on vulnerable Indian population. *New Microbes New Infect.* 2021;42:100903.
 - 152 Wion RK, Miller WR. The impact of COVID-19 on HIV self-management, affective symptoms, and stress in people living with HIV in the United States. *AIDS Behav.* 2021;25(9):3034–3011.
 - 153 Diaz MM, Cabrera DM, Gil-Zacarias M, et al. Knowledge and impact of COVID-19 on middle-aged and older people living with HIV in Lima, Peru [online]. *medRxiv.* 2021.
 - 154 Siewe Fodjo JN, Faria de Moura Villela E, Van Hees S, Vanholder P, Reyntiers P, Colebunders R. Follow-up survey of the impact of COVID-19 on people living with HIV during the second semester of the pandemic. *Int J Environ Res Public Health.* 2021;18(9):4635.
 - 155 Waterfield KC, Shah GH, Etheredge GD, Ikhile O. Consequences of COVID-19 crisis for persons with HIV: the impact of social determinants of health. *BMC Public Health.* 2021;21(1):299.
 - 156 Cooley SA, Nelson B, Doyle J, Rosenow A, Ances BM. Collateral damage: impact of SARS-CoV-2 pandemic in people living with HIV. *J Neurovirol.* 2021;27(1):168–170.
 - 157 Siewe Fodjo JN, Villela EFM, Van Hees S, et al. Impact of the COVID-19 pandemic on the medical follow-up and psychosocial well-being of people living with HIV: a cross-sectional survey. *J Acquir Immune Defic Syndr.* 2020;85(3):257–262.
 - 158 Marbaniang I, Sangle S, Nimkar S, et al. The burden of anxiety during the COVID-19 pandemic among people living with HIV (PLHIV) in Pune, India. *Res Sq.* 2020;20(1):1598.
 - 159 Kuman Tunçel Ö, Pullukçu H, Erdem HA, Kurtaran B, Taşbakan SE, Taşbakan M. COVID-19-related anxiety in people living with HIV: an online cross-sectional study. *Turk J Med Sci.* 2020;50(8):1792–1800.
 - 160 Ballester-Arnal R, Gil-Llario MD. The virus that changed Spain: impact of COVID-19 on people with HIV. *AIDS Behav.* 2020;24(8):2253–2257.
 - 161 Shiao S, Krause KD, Valera P, Swaminathan S, Halkitis PN. The burden of COVID-19 in people living with HIV: a syndemic perspective. *AIDS Behav.* 2020;24(8):2244–2249.
 - 162 Delle Donne V, Ciccarelli N, Massaroni V, et al. Psychological distress during the initial stage of the COVID-19 pandemic in an Italian population living with HIV: an online survey. *Infez Med.* 2021;29(1):54–64.
 - 163 Jones DL, Ballivian J, Rodriguez VJ, et al. Mental health, coping, and social support among people living with HIV in the Americas: a comparative study between Argentina and the USA during the SARS-CoV-2 pandemic. *Res Sq.* 2021;25(8):2391–2399.
 - 164 Errea RA, Wong M, Senador L, et al. [Impact of SARS-CoV-2 pandemic on adolescents living with HIV in Lima, Peru]. *Rev Peru Med Exp Salud Publica.* 2021;38(1):153–158.
 - 165 The parallel fight against HIV and COVID-19. *Lancet Reg Health West Pac.* 2020;5:100082.
 - 166 Shah I, Delia Pereira NM. HIV services in times of COVID-19. *Indian J Med Res.* 2020;152(6):533–534.
 - 167 Braunstein SL, Slutsker JS, Lazar R, et al. Epidemiology of reported HIV and other sexually transmitted infections during the COVID-19 pandemic, New York City. *J Infect Dis.* 2021;224(5):798–803.
 - 168 Burki T. HIV in the age of COVID-19. *Lancet Infect Dis.* 2021;21(6):774–775.
 - 169 Celestin K, Allorant A, Virgin M, et al. Short-term effects of the COVID-19 pandemic on HIV care utilization, service delivery, and continuity of HIV antiretroviral treatment (ART) in Haiti. *AIDS Behav.* 2021;25(5):1366–1372.
 - 170 Bhatt M, Soneja M, Gupta N. COVID-19 in patients living with human immunodeficiency virus (HIV) infection: challenges and way-forward. *Drug Discov Ther.* 2021;15(1):42–43.
 - 171 Sun Y, Li H, Luo G, et al. Antiretroviral treatment interruption among people living with HIV during COVID-19 outbreak in China: a nationwide cross-sectional study. *J Int AIDS Soc.* 2020;23(11):e25637.
 - 172 Qiao S, Yang X, Sun S, et al. Challenges to HIV service delivery and the impacts on patient care during COVID-19: perspective of HIV care providers in Guangxi, China. *AIDS Care.* 2021;33(5):559–565.
 - 173 Brown LB, Spinelli MA, Gandhi M. The interplay between HIV and COVID-19: summary of the data and responses to date. *Curr Opin HIV AIDS.* 2021;16(1):63–73.
 - 174 Quiros-Roldan E, Magro P, Carriero C, et al. Consequences of the COVID-19 pandemic on the continuum of care in a cohort of people living with HIV followed in a single center of Northern Italy. *AIDS Res Ther.* 2020;17(1):59.
 - 175 Pinto RM, Park S. COVID-19 pandemic disrupts HIV continuum of care and prevention: implications for research and practice concerning community-based organizations and frontline providers. *AIDS Behav.* 2020;24(9):2486–2489.
 - 176 Jiang H, Zhou Y, Tang W. Maintaining HIV care during the COVID-19 pandemic. *Lancet HIV.* 2020;7(5):e308–e309.
 - 177 Smith E, Badowski ME. Telemedicine for HIV care: current status and future prospects. *HIV AIDS (Auckl).* 2021;13:651–656.
 - 178 Coppock D, Quimby C, Nunez J, Whitener C, Zurlo J. People living with human immunodeficiency virus during the COVID-19 pandemic: experiences with telemedicine. *Health Promot Pract.* 2021;22(3):298–299.
 - 179 Patel VV, Beil R, Slawek D, Akiyama MJ. HIV prevention and treatment in the context of the COVID-19 in the Bronx, New York. *AIDS Rev.* 2020;22(3):143–147.
 - 180 Hoagland B, Torres TS, Bezerra DRB, et al. Telemedicine as a tool for PrEP delivery during the COVID-19 pandemic in a large HIV prevention service in Rio de Janeiro-Brazil. *Braz J Infect Dis.* 2020;24(4):360–364.
 - 181 Rogers BG, Coats CS, Adams E, et al. Development of telemedicine infrastructure at an LGBTQ+ clinic to support HIV prevention and care in response to COVID-19, Providence, RI. *AIDS Behav.* 2020;24(10):2743–2747.
 - 182 Auchus IC, Jaradeh K, Tang A, Marzan J, Boslett B. Transitioning to Telehealth during the COVID-19 pandemic: patient perspectives and attendance at an HIV clinic in San Francisco. *AIDS Patient Care STDS.* 2021;35(7):249–254.

- 183 Sorbera M, Fischetti B, Khaimova R, Niewinski M, Wen K. Evaluation of virologic suppression rates during the COVID-19 pandemic with outpatient interdisciplinary HIV care [published ahead of print]. *J Am Coll Clin Pharm*. 2021. <https://doi.org/10.1002/jac5.1422>
- 184 Rivera A, Martinez P, Braunstein S. Video-based HIV testing services among cisgender men who have sex with men as a component of an HIV behavioural surveillance study during the COVID-19 pandemic in New York City: implementation, feasibility and lessons learned [published ahead of print]. *Sex Transm Infect*. 2021. <https://doi.org/10.1136/sextrans-2021-055110>
- 185 Yelverton V, Qiao S, Weissman S, Olatosi B, Li X. Telehealth for HIV care services in South Carolina: utilization, barriers, and promotion strategies during the COVID-19 pandemic [published ahead of print]. *AIDS Behav*. 2021. <https://doi.org/10.1007/s10461-021-03349-y>
- 186 Winwood JJ, Fitzgerald L, Gardiner B, Hannan K, Howard C, Mutch A. Exploring the social impacts of the COVID-19 pandemic on people living with HIV (PLHIV): a scoping review [published ahead of print]. *AIDS Behav*. 2021. <https://doi.org/10.1007/s10461-021-03300-1>
- 187 Budak JZ, Scott JD, Dhanireddy S, Wood BR. The impact of COVID-19 on HIV care provided via telemedicine-past, present, and future. *Curr HIV/AIDS Rep*. 2021;18(2):98–104.
- 188 Htun Nyunt O, Wan NMA, Soan P, et al. How Myanmar is working to maintain essential services for people living with HIV and key populations during the Covid-19 pandemic. *J Int Assoc Provid AIDS Care*. 2021;20:23259582211017742.
- 189 Jiang H, Xie Y, Xiong Y, et al. HIV self-testing partially filled the HIV testing gap among men who have sex with men in China during the COVID-19 pandemic: results from an online survey. *J Int AIDS Soc*. 2021;24(5):e25737.
- 190 Nawej Tshikung O, Smit M, Marinosci A, et al. Caring for people living with HIV during the global coronavirus disease 2019 pandemic. *AIDS*. 2021;35(3):355–358.
- 191 Giuliani M, Donà MG, La Malfa A, et al. Ensuring retention in care for people living with HIV during the COVID-19 pandemic in Rome, Italy. *Sex Transm Infect*. 2021;97(4):317.
- 192 Wang H. HIV care during the coronavirus disease-2019 pandemic in Shenzhen, China. *Curr Opin HIV AIDS*. 2020;15(6):341–344.
- 193 Armbruster M, Fields EL, Campbell N, et al. Addressing health inequities exacerbated by COVID-19 among youth with HIV: expanding our toolkit. *J Adolesc Health*. 2020;67(2):290–295.
- 194 Harris NS, Johnson AS, Huang YA, et al. Vital signs: status of human immunodeficiency virus testing, viral suppression, and HIV preexposure prophylaxis – United States, 2013–2018. *MMWR Morb Mortal Wkly Rep*. 2019;68(48):1117–1123.
- 195 Posada-Vergara MP, Alzate-Angel JC, Martínez-Buitrago E. COVID-19 and VIH. *Colomb Med (Cali)*. 2020;51(2):e4327.
- 196 Mahmood K, Rashed ER, Oliveros E, et al. Predisposition or protection?: COVID-19 in a patient on LVAD support with HIV/AIDS. *JACC Case Rep*. 2020;2(9):1337–1341.
- 197 Hu Y, Ma J, Huang H, Vermund SH. Coinfection with HIV and SARS-CoV-2 in Wuhan, China: a 12-person case series. *J Acquir Immune Defic Syndr*. 2020;85(1):1–5.
- 198 Akyala AI, Iwu CJ. Novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) co-infection with HIV: clinical case series analysis in North Central Nigeria. *Pan Afr Med J*. 2020;37(47):47.
- 199 Chen J, Cheng X, Wang R, Zeng X. Computed tomography imaging of an HIV-infected patient with coronavirus disease 2019. *J Med Virol*. 2020;92(10):1774–1776.
- 200 Yamamoto S, Saito M, Nagai E, et al. Antibody response to SARS-CoV-2 in people living with HIV. *J Microbiol Immunol Infect*. 2021;54(1):144–146.
- 201 Mascolo S, Romanelli A, Carleo MA, Esposito V. Could HIV infection alter the clinical course of SARS-CoV-2 infection? When less is better. *J Med Virol*. 2020;92(10):1777–1778.
- 202 Del Amo J, Polo R, Moreno S, et al. Incidence and severity of COVID-19 in HIV-positive persons receiving antiretroviral therapy: a cohort study. *Ann Intern Med*. 2020;173(7):536–541.
- 203 Berenguer J, Díez C, Martín-Vicente M, et al. Prevalence and factors associated with SARS-CoV-2 seropositivity in the Spanish HIV research network cohort [published ahead of print]. *Clin Microbiol Infect*. 2021. <https://doi.org/10.1016/j.cmi.2021.06.023>
- 204 Dallochio RN, Dessì A, De Vito A, Delogu G, Serra PA, Madeddu G. Early combination treatment with existing HIV antivirals: an effective treatment for COVID-19? *Eur Rev Med Pharmacol Sci*. 2021;25(5):2435–2448.
- 205 Cao B, Wang Y, Wen D, et al. A trial of lopinavir–ritonavir in adults hospitalized with severe Covid-19. *N Engl J Med*. 2020;382(19):1787–1799.
- 206 Di Biagio A, Taramasso L, Dentone C, et al. Is a step-down antiretroviral therapy necessary to fight severe acute respiratory syndrome coronavirus 2 in HIV-infected patients? *AIDS*. 2020;34(12):1865–1867.
- 207 Alhumaid S, Mutair AA, Alawi ZA, Alhmeed N, Zaidi ARZ, Tobaqiy M. Efficacy and safety of lopinavir/ritonavir for treatment of COVID-19: a systematic review and meta-analysis. *Trop Med Infect Dis*. 2020;5(4):180.
- 208 Alavian G, Kolahdouzan K, Mortezaazadeh M, Torabi ZS. Antiretrovirals for prophylaxis against COVID-19: a comprehensive literature review. *J Clin Pharmacol*. 2021;61(5):581–590.
- 209 Hoffmann C, Casado JL, Härter G, et al. Immune deficiency is a risk factor for severe COVID-19 in people living with HIV. *HIV Med*. 2021;22(5):372–378.
- 210 Ader F, Peiffer-Smadja N, Poissy J, et al. An open-label randomized controlled trial of the effect of lopinavir/ritonavir, lopinavir/ritonavir plus IFN- β -1a and hydroxychloroquine in hospitalized patients with COVID-19 [published ahead of print]. *Clin Microbiol Infect*. 2021. <https://doi.org/10.1016/j.cmi.2021.05.020>
- 211 Amani B, Khanijahani A, Amani B, Hashemi P. Lopinavir/ritonavir for COVID-19: a systematic review and meta-analysis. *J Pharm Pharm Sci*. 2021;24:246–257.
- 212 Dorward J, Gbinigie O, Cai T, et al. The protease inhibitor lopinavir, boosted with ritonavir, as treatment for COVID-19: a rapid review. *Antivir Ther*. 2020;25(7):365–376.
- 213 Di Castelnuovo A, Costanzo S, Antinori A, et al. Lopinavir/ritonavir and darunavir/cobicistat in hospitalized COVID-19 patients: findings from the multicenter Italian CORIST study. *Front Med (Lausanne)*. 2021;8(639970):639970.
- 214 Services USDoHaH. Interim Guidance for COVID-19 and Persons with HIV. <https://aidsinfo.nih.gov/guidelines/html/1/adult-and-adolescent-arv/0>. Published 2020. Accessed August 25, 2020.
- 215 Services USDoHaH. Guidelines for the Use of Antiretroviral Agents in Adults and Adolescent with HIV. <https://aidsinfo.nih.gov/guidelines/html/1/adult-and-adolescent-arv/0>. Published 2020. Accessed August 25, 2020.