



# Impact of COVID-19 on HIV Prevention Access: A Multi-platform Social Media Infodemiology Study

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## Abstract

This study seeks to identify and characterize key barriers associated with PrEP therapy as self-reported by users on social media platforms. We used data mining and unsupervised machine learning approaches to collect and analyze COVID-19 and PrEP-related posts from three social media platforms including Twitter, Reddit, and Instagram. Predominant themes detected by unsupervised machine learning and manual annotation included users expressing uncertainty about PrEP treatment adherence due to COVID-19, challenges related to accessibility of clinics, concerns about PrEP costs and insurance coverage, perceived lower HIV risk leading to lack of adherence, and misinformation about PrEP use for COVID-19 prevention.

**Keywords** Infodemiology · HIV/AIDS · Minority health · PrEP · Social media

## Abbreviations

COVID-19	Coronavirus disease 2019
HIV	Human immunodeficiency virus
PrEP	Pre-exposure prophylaxis
AIDS	Acquired immunodeficiency syndrome
MSM	Men who have sex with men
STD	Sexually transmitted diseases
API	Application programming interface
SEPO	Social-ecological perspective outline
LGBTQ	Lesbian, gay, bisexual, transgender, and queer

## Introduction

The end of 2019 introduced new global challenges with the sudden emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In the weeks and months following its detection in the United States and other parts of the world, day-to-day activities of patients began to experience significant interruption due to implementation of stay at home, and social distancing measures needed to slow the escalating pandemic. While these measures reduced in-person interactions of disease transmission, they also created new challenges, including for HIV prevention [1, 2].

Prioritizing triage of COVID-19 cases created a shift in allocation of certain healthcare services [3]. Those most affected included patients seeking routine care, which includes individuals seeking HIV prevention services that require strict adherence to therapy, such as pre-exposure prophylaxis (PrEP) [4]. HIV negative individuals rely on PrEP to maintain negative HIV serostatus, yet many patients experienced reduced clinical visits during COVID-19, thus interrupting their PrEP therapy [5–7]. Those not on PrEP but at elevated HIV risk, require consultation with a healthcare professional to confirm negative status to be prescribed PrEP [8]. However, treatment barriers associated with commuting to appointments, completing necessary blood/lab work, and filling prescriptions, were all negatively impacted by COVID-19 [9, 10].

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Supporting the importance of maintaining access to HIV prevention services, a 2021 study used simulation models to estimate the benefits of continuing certain HIV prevention services (e.g., male circumcision, HIV diagnostic testing, viral load testing, and program to prevent mother-to-child transmission) and found that the risk of additional COVID-19-related deaths was at least 100 times less than HIV-related mortality that would be averted by prevention services [11]. Further, as more individuals at risk for HIV become sexually active due to removal of COVID-19 restrictions, the possibility of HIV transmission during a post-pandemic period may increase, necessitating more comprehensive understanding of barriers associated with PrEP access [10, 12]. This may also coincide with a time period where an increased number of HIV-negative individuals are reportedly engaging in riskier sexual and unsafe behaviors [13]. Hence, research examining the impacts of the COVID-19 pandemic on HIV prevention behavior is needed to address post-pandemic challenges, but interventions will also need to be tailored to specific vulnerable populations and diverse experiences.

Current HIV and COVID-19 research has documented interruption of HIV services and widening health disparities, yet few studies have attempted to identify the unique socioecological barriers that may have arisen due to COVID-19-related restrictions and its associated implications [14–16]. Hence, to better understand the evolving environment at the intersection of HIV and COVID-19, this study seeks to identify and characterize key barriers associated with PrEP therapy access using infodemiology approaches (i.e., the science of distribution and determinants of information in an electronic medium, with the aim of informing public health) [17]. Specifically, we conducted analysis of publicly available user-generated data from multiple social media platforms associated with PrEP and HIV prevention attitudes, beliefs, and experiences during the pandemic.

## Methods

### Data Collection

Data was collected from Twitter, Reddit, and Instagram simultaneously over a 60-day period (October 2020, until December 2020), including both retrospective (limited to posts after March 13, 2020, when COVID-19 was declared a national emergency in the United States) and prospective data. We chose these platforms based on their general popularity, accessibility of data, and diversity in user base and different methods of online communication and interaction (e.g., a microblogging site [Twitter], a news aggregation and discussion site [Reddit], and a photo and video platform [Instagram]). We first generated a list of PrEP and

HIV associated keywords and hashtags by manually searching posts on selected social media platforms, which generated a baseline set of terms associated with HIV, PrEP, and approved medications. This was accomplished by conducting structured searches of a set of initial keywords and then collecting additional hashtags and keywords associated with HIV prevention and treatment content from the first 100 post results. This allowed us to generate the final list of selected keywords and hashtags used for this study's data collection phase (see Supplementary File). We used multiple data collection approaches including the public streaming Twitter API and automated data mining approaches built in the programming language Python to collect posts from Reddit and Instagram. This study focused on analysis of English-language posts but did not include a geographic restriction. As this study only utilized secondary publicly available data, it was deemed exempt by WCG IRB. WCG IRB is registered with the Office for Human Research Protections and US Food and Drug Administration (FDA) as IRB00000533. Data was collected for purposes of aggregation, and no results contained in this study include individually identifiable information.

### Data Analysis

#### Content and Statistical Analysis

In this study, relevant “signal” posts were defined as user-generated posts from Twitter, Instagram, or Reddit accounts discussing PrEP and/or general HIV prevention practices and also mention of COVID-19. To identify signal posts, we adopted a combination of keyword filtering, unsupervised machine learning using the Biterm Topic Model (BTM), as well as manual annotation by further filtering our dataset for COVID-19-related keywords in the text of user posts (e.g., “covid19,” “corona,” “coronavirus,” and “coronavirus19” [18]). The Biterm Topic Model is an unsupervised machine learning approach used to detect patterns in data and can summarize the entire corpus of text into distinct highly correlated categories. BTM can be used to sort short text into highly prevalent themes without the need for predetermined training data and has been previously used for exploration of other public health topics [19–24]. The methodological approach of using BTM for detection of HIV and PrEP-related topics is also detailed in a separate published paper [25].

The inclusion criteria for signal posts included user-generated conversations where knowledge, attitudes, behaviors, or experiences regarding PrEP or general HIV prevention methods were discussed, as well as information associated with public service announcements and health promotion and education messages specifically posted or shared from an individual user account. Public service announcements, health

promotion and education messages posted from organizations (i.e., not individual accounts), advertisements for HIV prevention services/clinics that were posted by an organization, and other conversations not related to HIV prevention or that appeared not to be user-generated were excluded.

A general deductive coding schema using the socio-ecological perspective outline (SEPO) [26] that outlines three intervention levels for PrEP including the “Individual and Relationships Domains: Provider Level”, “Individual and Relationships Domains: Patient Level” and “Community Domains: Healthcare-System Level”, were selected as parent codes as used in a prior PrEP infodemiology study [25]. All posts were reviewed by first and second author, and notes were taken on general themes of posts from which an initial code list was created. SEPO categories of PrEP barriers were adopted as subcodes throughout our deductive coding and subcodes not detected were excluded from the final codebook. Emergent themes that did not present in existing subcodes were added to the codebook under the three parent codes based on the conceptual domain and intervention level of the new theme. First and second author achieved a strong intercoder reliability (Cohen’s kappa coefficient  $\approx 0.88$ ) for codes generated. For inconsistent results, all authors reviewed the posts and reached consensus on correct classification.

Chi-square tests were used to examine if the proportion of user conversations varied among: (i) provider-level; (ii) patient-level; and (iii) community-level between Twitter and Instagram. Fisher’s exact tests were used to determine significant proportional differences in user conversations on Reddit due to smaller sample size. All statistical analyses were conducted using RStudio version 4.1.2. A p-value of  $< 0.05$  was considered statistically significant.

### User Race, Ethnicity, and Sexual Minority Assessment

Given the disproportionate impact of COVID-19 on HIV treatment access, disease burden, and pre-existing socio-economic and health disparity-related barriers, we also reviewed publicly available information from users to assess self-reported information related to: (1) a racial and ethnic group; and (2) a specific sexual minority group. We reviewed user profile metadata and the content of the last 10 posts from each user account for any self-reported racial, ethnic, or sexual minority affiliation (e.g., “As a sexually active black gay man in a major metropolitan area”, and “I am a black man in New York...”). The racial and ethnic groups categorized included: Black or African American, American Indian or Alaska Natives, Asian, Native Hawaiian or other Pacific Islander, and Hispanic or Latino. The five sexual and gender minority classification were lesbian, gay, bisexual, transgender, and queer (LGBTQ) and were grouped as a single sexual minority affiliation class. In addition to racial, ethnic, and sexual minority self-reported data,

we also reviewed user account information and posts for any mention of geographic location. User data are users who reported their location in the United States.

## Results

A total of 267,689 posts were collected from Twitter, Reddit, and Instagram using our HIV and PrEP-related keywords and hashtags between March 13, 2020 and December 11, 2020, a time of relatively high COVID-19 pandemic activity and when vaccines had not been readily available or administered to the general public. The dataset comprised of 254,122 (94.93%) Twitter posts, 11,218 (4.19%) Instagram posts, and 2349 (0.88%) Reddit posts. After filtering for COVID-19-related terms, the total corpus of posts was reduced to 11,222 (4.19% of the total dataset) comprised of 7620 (67.90%) Twitter, 3278 (29.21%) Instagram, and 324 (2.89%) Reddit posts. After using BTM on the higher volume of Twitter posts, and manual annotation for Instagram and Reddit posts, a total of 317 signal posts were detected (2.82% of entire dataset), of which we detected 190 (59.94% of signal posts) signal posts from Twitter, 109 (34.38%) from Instagram, and 18 (5.68%) from Reddit (See Supplementary File), which were then content coded for further in-depth analysis. A summary of SEPO parent and sub-code results are reported in Table 1 with corresponding de-identified examples from different sexual minority and racial and ethnic minority users.

### Content and Statistical Analysis

SEPO provider-level conversations generated 100 posts (31.55% of all signals) and were focused on perceived provider decision making barriers reported by social media users. PrEP-related user discussions focused on concerns about accessibility to STD and HIV clinics due to reduced operation during COVID-19, with the highest volumes occurring on Twitter (68%,  $n = 17$ ) and Instagram (32%,  $n = 8$ ). Another PrEP-related topic focused on the provision of HIV testing and prevention services (i.e., HIV testing in conjunction with PrEP) and made up the third-highest volume of user conversations at the provider level. However, more than half (58%,  $n = 58$ ) of topics in this level focused on information and resources for non-PrEP HIV prevention approaches, including access to free HIV self-testing kits and condoms, aimed at mitigating spread due to unsafe sex during COVID-19.

Patient-level user conversations, which focused on barriers at the patient decision-making level, had the highest total signal in the dataset ( $n = 116$ , 36.59% posts). The majority of these posts came from Twitter (73.28%,  $n = 85$ ), followed by Instagram (22.41%,  $n = 26$ ), and Reddit (4.31%,  $n = 5$ ). A major theme that emerged was widespread discussion of

**Table 1** Deductive code list and identified sub-codes based on SEPO

Topic level	Code number	Description	Examples (de-identified and paraphrased)	Twitter	Instagram	Reddit	Total
Provider level (31.55% of all signals)	A-1	Providing free HIV self-test kits	“During the time of COVID, it is important to continue to test yourself for any HIV infection. Today, we are offering free HIV home tests mailed directly to you confidentially. All information submitted will be anonymously. #HIVtest #gettested #hivawareness #hivprevention #hivpositive #hivtesting #gay #lesbian #bisexual #trans #transgender”	2	41	0	43 (43.00%)
	A-2	Providing free STD prevention (condom)	“Protect yourself from potential infections. It’s important to rubber up before engaging in activities. Message us today so we can send you free condoms. You never know when you will need to use them.”	0	15	0	15 (15.00%)
	A-3	Providing HIV medical and prevention services (HIV test and PrEP)	“At home testing kits for long term adherence to #PrEP is one way to verify if PrEP has been working well for you to prevent #HIV. Contact us to see how we can assist you! #COVID #telehealth”	7	10	0	17 (17.00%)
	A-4	Concerns regarding reduced operation of STD and HIV clinics during COVID	“Testing for your status for HIV is important. The pandemic may have impacted availability and locations to go near you, but there are options to test yourself. If that isn’t an option you can also do virtual PrEP clinic with a pharmacist available 7 days a week. #queer #prep #theprep-clinic # hivprevention #harmreduction #knowyourstatus #hivtesting #safersex	17	8	0	25 (25.00%)
Total				26	74	0	100
Patient Level (36.59% of all signals)	B-1	Distrust of HIV prevention	“B*****! It’s all about control. Covid is no different than HIV. They want you to take something into your body because it can prevent you from illness. What’s next? They can’t take my rights away, I decide what goes into my body	6	0	0	6 (5.17%)
	B-2	Experienced lack of access to PrEP and HIV treatment during COVID	“Ever since COVID-19 began, its been very difficult to get tested for HIV in hospitals 🙄. I think clinics are a better option.”	22	7	2	31 (26.72%)

Table 1 (continued)

Topic level	Code number	Description	Examples (de-identified and paraphrased)	Twitter	Instagram	Reddit	Total
	B-3	Concern of lack of funding and resources for HIV prevention	“@***** @***** @ ***** I overheard a few people at my clinic talking about how they might double count patients who visit for HIV, so they don't lose funding. I wonder if they do that for other diseases?”	2	0	0	2 (1.72%)
	B-4	User claims in support of PrEP therapy	“Mask up during COVID. Been on PrEP for years and I can say the medication works well. It's HIV blocking abilities are a life saver. However, I did het Hep-c a few years back from sex alone. That was disappointing but oh well. Just you PrEP. It works!”	4	0	0	4 (3.45%)
	B-5	Patient reacquiring access to PrEP treatment	“Now that the lockdowns are over and our case counts are near 0 maybe it's time to get back on PrEP. Its time to have fun this year!”	2	0	0	2 (1.72%)
	B-6	Expressions that users should be aware of COVID-19-related risks (people having sex and at risk)	“Screaming at this F**** who told me he doesn't hookup without condoms, and he feels like he did something for denying a guy he met on grinder who didn't want condoms because he uses PrEP. Like honey, condoms won't protect you from COVID. What are you doing?”	3	0	0	3 (2.59%)
	B-7	Recommend other users to engage in HIV prevention efforts (testing, PrEP, condom use)	“If you test negative for #HIV that doesn't mean you no longer need condoms, PrEP or other effective prevention strategy. Kinda like a negative #COVID test doesn't mean you don't have to socially distance.”	13	18	0	31 (26.72)
	B-8	Self-perceived reduced risk due to reduced sexual behavior	“I stopped using PrEP (COVID) since I can't do anything with these lockdowns”	19	1	3	23 (19.83%)
	B-9	Users think they immune to COVID because they are on PrEP	“People are crazy today. They think taking one medication will protect them from others diseases. Come on people. Taking PrEP doesn't protect you from STD like chlamydia or the COVID virus. Hell, it won't save you from your own stupidity 😏”	14	0	0	14 (12.07%)
Total				85	26	5	116
Community Level (31.86% of all signals)	C-1	Opinion that COVID lowers rate of HIV (due to social distancing)	“While COVID is terrible overall, I think all these lockdowns may have a benefit towards lowering STI rates. Can you imagine”	1	0	0	1 (0.99%)

Table 1 (continued)

Topic level	Code number	Description	Examples (de-identified and paraphrased)	Twitter	Instagram	Reddit	Total
	C-2	Financial impact caused by COVID pandemic increased sex worker number and could lead to higher STI and HIV rates	<p>“One of the saddest things I have seen is the increase funds for boys and girls. In 24 h, I have been contacted by 9 people offering sex for money. Some are people who lost their jobs because of covid. I decline them and try to give them support, but it sad that 93% of sex workers have contracted at least one STI before. I feel that this pandemic will increase the overall percentage. #HIV #HIVprevention #NoPrEPforme #gettested2020 #safesex #sexwork”</p> <p>“Hospitals are being overrun by COVID patients. I was watching the news that emergency vehicles likes ambulances will have to treat those who are positive for covid before other patients. What if I have a broken bone that needed to be looked at. Or what if I have a heart attack? Am I supposed to wait until the pandemic is over for help? Will this affect any of my medication like PrEP or my typical screening with my primary doctor? I hope I can still get medical help when it's needed. If not, I'll be pissed.” #covid19 #covid19PH #coronavirus #safesex #SafeSexA-wareness #RH #RHLaw #birthcontrol #HIV #HIVprevention #womenshealth #genderequality #genderequalityforall #genderequalitymatters</p>	0	1	0	1 (0.99%)
	C-3	Health resources being prioritized for COVID-19 instead of HIV	<p>“COVID hasn't put HIV or STI infections to sleep. They are still being transmitted and we need adequate sexual health services for them!”</p> <p>“Exciting news! New covid taskforce discussed a highly effective two-dose COVID vaccine! Also, a more effective PrEP drug for HIV! It's about time! 🙌🙌”</p> <p>“Lots of distrust circling on social media. People are taking anything to prevent COVID. Heck, some of my friends think that PrEP can also protect them from COVID since it protects them from HIV transmission.”</p>	9	2	0	11 (10.89%)
	C-4	Lack of focus on HIV prevention		7	0	0	7 (6.93%)
	C-5	New technology discussions for PrEP		26	1	0	27 (26.73%)
	C-6	PrEP used as a prevention method for COVID-19		31	0	12	43 (42.57%)

Table 1 (continued)

Topic level	Code number	Description	Examples (de-identified and paraphrased)	Twitter	Instagram	Reddit	Total
	C-7	Sharing knowledge on HIV prevention when users lack access to PrEP	“In some way we have several layers of protection to prevent the spread of HIV. Even if you can't get access to PrEP, many organizations provide condoms for those who are on a budget. #SafeSexAlways #StopTheStigma”	3	2	1	6 (5.94%)
	C-8	Sharing general PrEP knowledge	“Pre-exposure prophylaxis (PrEP) is a medication that prevents HIV infection. PrEP is free for those who are considered to be substantial high risk of contracting HIV via sex. However, because of COVID, some appointments services may be affected. #sexwellbeing”	1	3	0	4 (3.96%)
	C-9	Discussion of stigma experienced by use of PrEP	“I can understand why people look at me differently when I tell them I'm on PrEP. It's not that I have HIV, but I'm trying to prevent myself from acquiring it. I wish that people would think and educate themselves before they speak.”	1	0	0	1 (0.99%)
	Total			79	9	13	101



resource allocation, with concerns that resources were being taken away from PrEP due to the COVID-19 surge (26.72%,  $n = 31$ ). Another topic included discussions encouraging consistent HIV testing, PrEP adherence, and condom use to prevent HIV transmission ( $n = 31$ , 26.72%). Users also discussed their relative risk associated with HIV and COVID-19 (19.83%,  $n = 23$ ), including self-reporting reduced sexual behavior and perceived lower risk due to social distancing, leading to termination of PrEP and other HIV prevention methods. A final sub-topic included incorrect information about the use of PrEP in providing immunity for COVID-19 (12.07%,  $n = 14$ ).

Community-level conversations accounted for 101 (31.86%) signal posts and focused on perceived barriers influenced at the macro community level. Prominent sub-topics included similar incorrect conversations that PrEP could be used as a prevention method or precaution against COVID-19 infection (42.57%,  $n = 43$ ) and discussions of new technology for PrEP (26.73%,  $n = 27$ ) (e.g., clinical trials investigating alternatives to delivering PrEP therapy, including administration via injection in lieu of daily adherence to medication). Specifically, Reddit conversation threads included many questions about PrEP being effective as a protective measure against COVID-19 infection. Other themes included opinions that there was a general lack of commitment to HIV prevention services, including PrEP, due to COVID-19.

Between Twitter and Instagram, provider-level user conversations were significantly more likely on Instagram and patient-level user conversations were significantly more likely on Twitter,  $X^2(1, N = 211) = 51.96$ ,  $p < 0.001$ . Community-level user conversations were significantly more likely on Twitter compared to provider-level conversations on Twitter,  $X^2(1, N = 188) = 74.64$ ,  $p < 0.001$ . Patient-level user conversations were significantly more likely on Twitter than Instagram compared to community-level user conversations,  $X^2(1, N = 199) = 5.02$ ,  $p = 0.03$ . Overall, comparing Instagram and Reddit, the proportion of patient-level user conversations was significantly more likely on Instagram and community-level user conversations were significantly more likely on Reddit (Fisher's exact test  $p = 0.002$ ).

### Self-reported Racial/Ethnic/Sexual Minority Data and Location Data

Using publicly available data from user accounts and their metadata, we were also able to identify 34 (10.73%) users that reported affiliation with one or more of the five sexual minority classifications. Additionally, we also classified users based on affiliation with racial minorities, which included 13 (4.10%) Black or African American and 2 (0.63%) Asian users; and affiliation with ethnic minorities including 2 (0.63%) Hispanics or Latino social media users.

A total of 253 (79.81%) unique users did not have sufficient information available to be identified into a specific racial group, 288 (90.85%) users were not able to be identified into a specific ethnic group, and 283 (89.27%) users were not able to be identified into a sexual minority group. We also did not assess if users self-reported as non-Hispanic white users. No users self-identified as Native Hawaiian and other Pacific Islander (See Table 2). Additionally, we were able to collect self-reported location data from 154 Twitter users, and 12 Instagram users. We observed that users reported they resided in 23 countries, and based on the number of users, the top three countries were the United States (89 Twitter users and 8 Instagram users), United Kingdom (31 Twitter users and 3 Instagram users), and Australia (10 Twitter users).

### Conclusions

Findings from this exploratory infodemiology study largely confirm what is already known; the COVID-19 pandemic contributed to disruptions for HIV prevention services that may impact uptake and adherence to PrEP therapy and other HIV prevention services. Importantly, these challenges are accentuated for ethnic, racial, and sexual minority populations. Our analysis of just over a quarter million social media posts from three platforms yielded 317 specific user-generated posts expressing attitudes, knowledge, and experiences associated with PrEP, HIV prevention services, and COVID-19. Thirty-seven users reported a sexual minority affiliation (LGBTQ status), making this the largest online user group we detected engaged directly in these conversations. Additionally, 17 users self-reported as a racial or ethnic minority group.

Results from this study provide insights into the specific barriers experienced across the HIV/AIDS PrEP care continuum during the COVID-19 pandemic as expressed by users from different social media platforms. Results indicate that certain barriers to PrEP are reported, experienced, perceived, and shared by users across multiple socioecological levels, while other barriers are unique to specific levels. For example, all levels reported perceived barriers to HIV prevention and PrEP access due to resource constraints (e.g., reduced clinic operation, not being able to access treatment due to lockdowns, resources being diverted or prioritized for COVID-19 instead of HIV prevention), while users also actively shared resources about HIV testing, PrEP, and other prevention methods. Shared challenges and information sharing requires a more comprehensive and coordinated approach to promoting HIV prevention, including targeted patient and provider advocacy for PrEP therapy and active community engagement, including through social media channels.



**Table 2** User identified minority status breakdown

Platform	Racial categories			Ethnic categories			Sexual minority		
	African American/Black	Asian	White	Hispanics or Latino	Not Hispanics or Latino	Missing identification	LGBTQ	Non-sexual minority	Missing identification
Instagram (% of Instagram users)	0 (0%)	0 (0%)	5 (4.59%)	1 (0.92%)	6 (5.50%)	102 (92.58%)	3 (2.75%)	0 (0%)	106 (97.25%)
Reddit (% of Reddit users)	1 (5.56%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	18 (100%)	10 (55.56%)	0 (0%)	8 (44.44%)
Twitter (% of Twitter users)	12 (6.32%)	2 (1.1%)	44 (23.16%)	1 (0.53%)	21 (11.05%)	168 (88.42%)	21 (11.05%)	0 (0%)	169 (88.95%)
Total	13 (4.10%)	2 (0.63%)	49 (15.46%)	2 (0.63%)	27 (8.52%)	288 (90.85%)	34 (10.73%)	0 (0%)	283 (89.27%)

Shared experiences across all SEPO levels may also help to characterize the overall risk environment that emerged due to COVID-19 and its impact on PrEP. This impact appears to be most acutely expressed at the patient level, where users reported a number of different topics ranging from changing behaviors and attitudes with PrEP and HIV prevention (including disruption and even deciding to forego PrEP) and also reassessing their own HIV/AIDS risk in response to pandemic conditions (deciding they were at lower risk for HIV and ceasing PrEP). Unfortunately, users at the patient-level also expressed distrust and circulated incorrect and misinformation about the use of PrEP to prevent COVID-19 transmission, a phenomenon also detected at the community-level, even though there is no evidence to support these claims. These concerns mirror warnings issued by public health officials on various forms of misinformation related to COVID-19 prevention and treatment [18]. In response, tailored education and “debunking” of these claims specific to the HIV community is needed in alignment with other efforts to combat growing health misinformation online [27].

Additionally, the provider, patient, and community level challenges we detected may serve to exacerbate other documented challenges with HIV prevention uniquely experienced by ethnic, racial, and sexual populations, including ongoing stigma, deep rooted fear of HIV, increased stress and mental health impact, lack of equitable access to treatment and lower adherence rates, and overall disproportionate HIV burden [28]. Hence, generating better understanding and addressing the specific barriers that may disproportionately impact these vulnerable groups needs to be addressed synergistically across all socio-ecological levels and across the HIV prevention and care continuum, particularly during health emergencies [29].

### Limitations

This study is primarily exploratory and has certain limitations. We only collected data from three social media platforms and limited our analysis to English language keywords and filtered terms to a specific time period during the COVID-19 pandemic. Hence, the findings are not generalizable to all social media users who discuss and experience PrEP-related barriers or can be generalized to all stages of the pandemic. Specifically, data analyzed in this study covered a period after COVID-19 was declared a U.S. public health emergency until the date when the first COVID-19 vaccine became readily available to the public. Hence, access to and maintenance of HIV prevention services, such as PrEP, may have been impacted by different pandemic developments, necessitating additional analysis at specific stages of the pandemic to assess cumulative impacts on at-risk HIV populations. Future studies should

also expand data collection to different languages and phrases associated with HIV prevention and risk behavior, as well as longer time periods, to generate a more representative corpus of social media conversations. We also used keywords to filter posts for manual annotation after applying an unsupervised topic modeling approach. However, posts that did explicitly contain COVID-19-related keywords that occurred during the pandemic or that may have occurred outside our study period, may have also yielded valuable insight into additional PrEP-related barriers experienced by online users. Future studies should analyze a larger dataset of user-generated conversations by developing additional supervised and unsupervised machine learning approaches to classify content. Additionally, the oversampling of tweets in our dataset due to greater data availability from the Twitter API could result in a bias sample of posts when compared to other platforms. Finally, we used self-identified or self-reported racial or ethnic minority affiliation and sexual minority affiliation and did not further cross-validate this user representation, which may further limit the applicability of findings specific to these groups.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s10461-022-03922-z>.

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**Clearance:** This article reflects the views of the authors and should not be construed to represent FDA's views or policies.

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**Data Availability** Not applicable.

**Code Availability** Not applicable.

## Declarations

**Conflict of interest** QX, TMM, HG, MCN, MC, JL, and TKM are employees of the startup company S-3 Research LLC. S-3 Research is a startup funded and currently supported by the National Institutes of Health – National Institute of Drug Abuse through a Small Business Innovation and Research contract for opioid-related social media research and technology commercialization. Authors reports no other conflicts of interest associated with this manuscript.

**Ethical Approval** As this study only utilized secondary publicly available data, it was deemed exempt by WCG IRB. WCG IRB is registered with the Office for Human Research Protections and US Food and Drug Administration (FDA) as IRB00000533. Data was collected for purposes of aggregation, and no results contained in this study include individually identifiable information.

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**Consent to Publication** Not applicable.

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