From virus to viral: content analysis of HIV-related Twitter messages among young men in the U.S.

Yunwen Wang[1,2*†], Jacqueline Ann Bannon[3†], Natalia Roszkowska[4], Essence Lynn Wilson[5], Stephen Bonett[6], Elizabeth Lazarus[7], Nadia Dowshen[8,9] and Robin Stevens[5]

Abstract

Background Adolescents and young adults account for over 21% of new HIV infections in the U.S. with most new cases among young men. As an important information source for this group, social media can uniquely reveal the perspectives and communicative patterns of this key population. We identified 6,439 young male Twitter users (ages 13–24) in the U.S. using an NLP pipeline with geolocations. From their Twitter timelines, we collected 24,600 HIV-related tweets, among which the most retweeted and favorited tweets ($n = 472$) were analyzed through a content analysis.

Results Three themes arose in this online viral discourse around HIV among young men: (i) *othering*, (ii) *politics and activism*, (iii) *risk and wellness*. *Othering* tweets contained stigmatizing jokes and insults alienating individuals who identify as lesbian, gay, bisexual, transgender, queer or questioning, intersex, asexual, or being elsewhere on the gender and sexuality spectrum (LGBTQIA +), and people with HIV. *Politics and activism* tweets discussed awareness, stigma, HIV criminalization, violence, LGBTQIA +, and women's rights. *Risk and wellness* tweets discussed risk behaviors for sexually transmitted infections (STIs) (e.g., condomless sex, transactional sex, multiple sexual partners), or safer sex and preventive practices (e.g., pre-exposure prophylaxis [PrEP], condom use, achieving undetectable viral load, medication adherence, and STI testing).

Conclusion The social acceptability of high-risk sex behaviors is high among young male Twitter users. Given the double-edged nature of social media—health-promoting (e.g., awareness, health activism) as well as risk-promoting (e.g., risky behavior endorsement, identity attacks)— this population may benefit from targeted health communication intervention. Future HIV prevention efforts should counter the stigma, misinformation, and risk-promoting viral messages prevalent on social media.

Keywords Social media, Viral messages, Young men, Stigma, HIV, Health promotion

†Yunwen Wang and Jacqueline Ann Bannon contributed equally to this manuscript.

*Correspondence:
Yunwen Wang
yunwen.wang@ku.edu
Full list of author information is available at the end of the article

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Adolescents and young adults (ages 13–24) account for over 21% of new human immunodeficiency virus (HIV) infections within the United States (U.S.) with most of these new cases being among young men who have sex with men [1]. Despite high infection rates among this age group, they are least likely to be aware of their HIV status compared to other age groups [1]. Furthermore, young people living with HIV have the lowest rate of viral suppression compared to other age groups [1]. Given these trends, this study aims to understand how young people use HIV-related content on social media platforms, which will provide insights towards preventative measures for reducing the risk of HIV infection among this demographic.

Social media is a widely used communication tool for adolescents and young adults [2–4] with upwards of 84% of U.S. young adults reporting use of at least one social media platform [5]. These platforms are one of the primary sources of information for sexual health and HIV prevention [6–9]. Between 25–33% of youth collect and distribute content pertaining to sex online [10–14]. Due to its wide reach, social media has frequently been used for health interventions including the promotion of HIV prevention programs [15], especially among those with limited access to healthcare and healthcare information [16].

Social media differs from traditional media as youth are not only exposed to content, but they create and respond to messages online. In this study, we conceptualize Twitter as a digital space where youth build community as well as contribute and co-create the messages we analyze. Youth like, favorite, repost, comment, and sometimes upvote or downvote social media messages, and a fraction of these messages have the potential to go viral, increasing their exposure [17].

Virality

The virality of online messages has been defined in multiple ways. One of the most comprehensive definitions comes from Alhabash and McAlister [18], which consists of three aspects: viral reach, affective evaluation, and message deliberation. Viral reach is characterized by the propagation of messages (e.g., sharing, forwarding, retweeting) among social media users, and on Twitter it can be measured by the number of retweets. Affective evaluation concerns a message's elicitation of emotions in the audience, and on Twitter it can be indicated by the number of favorites of a tweet. Lastly, message deliberation intends to capture "users' active and public deliberation of online messages" [[18], p. 1319], such as commenting. Online virality implies more message access, viewership, and engagement [18]. Therefore, studying popular social media messages,

or messages of virality potentials, among adolescents and young adults can invaluably unravel the discursive patterns in this population and the salience they assign to issues. As adolescents and young adults can be affected by adverse outcomes associated with online risk-promoting messages [19], the discursive patterns and the salience of topics among this group over issues such as HIV can inform health communication tailored to them.

Within the field of health communication, previous research has highlighted the significance of studying health-related viral messages. Studies in this regard have involved measuring the virality of messages posted by health organizations on WeChat [20], identifying the characteristics of health-related viral messages on Weibo [17], and testing factors predicting the sharing of opioids-related messages on Twitter [21]. For example, the study of Liu et al. [17] found that authority, privacy, evidence, and incentive appeals predicted the virality of health messages on Weibo, a microblog social networking site that is often compared as Twitter [17]. Yet, regarding HIV-related discussion on Twitter, it remains unknown what types of Twitter messages are viral among adolescents and young adults (ages 13–24).

Twitter as the digital neighborhood facilitating co-construction

According to Fox's research [22], virality of health messages may incur positive health-related outcomes by facilitating online discussion, information exchange, and social support. As mentioned above, social media users are not only exposed to content, but they create and respond to messages online. In addition to publicly sharing perspectives and personal narratives in networked online communities, or what has been termed as "digital neighborhoods" [3], adolescents and young adults co-construct generational culture and navigate meaning making by knowingly or unknowingly deciding the salience of certain discourses over others among their peers.

We frame our study following the co-construction theory [23], which posits a link between offline and online interactions. According to the co-construction theory [23], the posts of adolescents and young adults on social media are likely to reflect their offline attitudes and behaviors. They turn to social media to engage, share, and seek sexual health information. Social media can also reflect their current sense of identity or idealized self for a broader audience [24].

Several studies have found an association between sharing sexual content on social media and HIV risk behaviors. One study of young adults found that participants were significantly more likely to report engagement in unprotected sex after they viewed sexually suggestive images through social media platforms [25].

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A recent meta-analysis [26] of 27 studies with 67,407 adolescents ($M_{age} = 15.5$, range: 12.6–18.0 years; 51.7% girls; 57.2% White) also found small-to-medium positive correlations between social media use and substance use ($r = 0.19$, 95% CI = 0.12–0.26), and risky sexual behaviors ($r = 0.21$, 95% CI = 0.15–0.28). Our qualitative content analysis of Twitter posts adds to this literature by providing rich insight into young men's online sharing of attitudes and experiences related to sex, which can influence their adoption of risky or protective behaviors offline.

Twitter, initially designed as an online tool for discussion and dissemination of ideas, has evolved into a significant public space for health and policy discourse [27]. Several studies have demonstrated the relation of online discourse on Twitter and other social media to offline sexual health behaviors related to HIV or HIV incidence at the aggregate level [28–30]. In our previous quantitative work on HIV tweets nationally, we found that counties with higher numbers of tweets about HIV also had smaller incidences of HIV cases in the following year [30]. The relationship between Twitter posts and HIV prevention activities in the population is tempered by the presence of stigmatizing messages online. Stigma is significantly associated with reduced willingness to get tested for HIV [16, 31]. Despite increased online discussion on HIV testing being related to increased testing behaviors, stigma remained as a major barrier for getting tested [29]. Therefore, it is critical to examine the stigmatizing content in HIV-related discourse on Twitter.

Despite current evidence, few studies have conducted an in-depth examination of the content of HIV-related Twitter messages. Instead, most studies employ computational methods like natural language processing (NLP) to quantify the use of keywords and phrases in large data samples. The limitation of computational approaches is that they often lack analysis of the language, meaning, and context [32]. Computational approaches alone provide limited insight into the varied nature of online discourse about HIV-related attitudes and behaviors. The purpose of this study is to describe the discourse related to HIV on Twitter among young men in the U.S through an in-depth qualitative content analysis, examining dominant themes that support or retract from the uptake of HIV prevention behaviors. As social media is an important information source for this young group, studying online HIV discussions among young men provides a unique opportunity to understand the perspectives and communicative patterns of this key population for designing more tailored digital health interventions.

Methods

Data source

To retrieve the public tweets, we used the Twitter "garden hose" application programming interface (API) to randomly sample 1% of publicly available tweets posted between January 1st, 2016, and December 31st, 2016. Since we only focused on tweets, our study was exempted from review for being considered as non-human subjects research by the Institutional Review Board (IRB) of our university.

We limited our sample to only include users who tweeted at least 500 words in 2016, which is often the floor for identifying active users. The sampled users were geolocated in the U.S.; geolocation was determined either by tweet-specific latitude/longitude coordinates or by self-reported location information in their user profile. This sample was then filtered to include only users of predicted male gender and predicted age 13–24 ($N = 336,000$ users) using previously developed NLP classification procedures [33].

Next, we developed an HIV-related keyword list informed by existing literature and the expertise of a youth advisory board. The in-depth keyword list included terms, phrases, and emojis related to HIV, AIDS, HIV testing, pre-exposure prophylaxis (PrEP), condoms, multiple sexual partners, STIs, and sexual risk behavior, and was iteratively refined by the research team to exclude irrelevant terms and add additional terms as needed. This keyword list was used to extract a sample of 6,439 users (a subset of the 336,000 users) who posted HIV-related tweets from the Twitter API.

We then collected the full timelines (i.e., the entire collection of tweets posted by the user from 2009 to 2017) for the 6,439 sampled users, and again applied our keyword list as a filter to obtain only HIV-relevant tweets from them. Non-English tweets were identified using existing open-source algorithms [34, 35] and removed. Tweets with links to commercial pornography websites were removed using a classifier designed by the research team (75.7% out-of-sample prediction accuracy). We also removed tweets that were reported by Linvill et al. [36] to be possibly linked to Russian-affiliated bot accounts. This procedure yielded 24,600 HIV-related tweets from users predicted to be young men in the U.S.

For this analysis, we conducted a qualitative analysis of a subset of tweets that were both posted by individual users (as opposed to institutional users affiliated with public health agencies, social service organizations, or advocacy groups) and which received active engagement from other users through one or more retweets. Our final corpus of tweets for analysis included 472 tweets.

Data analysis

We conceptualize tweet virality as the extent to which tweets were retweeted or favorited, following Alhabash and McAlister's definition of virality [18]. Retweeting and favoriting a tweet are two important ways a user engages with a tweet [37]. Retweeting allows the original post to amass more retweets that are visualized through a tag updated in real-time and located beneath the message. Retweeting also brings the post to the home page of the user who retweets it and to the timeline of the retweeter's followers. Both retweeting mechanisms increase exposure of the message in the public sphere through message propagation. The favoriting function, in comparison, adds an immediate one-point increase in the post's number of favorites. The number of favorites, sequentially, is carried along by the post when it attracts a new viewer, potentially gaining more attention as the number of favorites increases.

The analysis of the tweet content was informed by Subrahmanyam and colleagues' adapted co-construction model [23]. Coders assessed themes and subthemes to understand how the physical, social, and digital environments interact and, in turn, best reflect youth and adolescent experiences. Coders were trained as a team in content analytic methods by the research lead using a similar sample of tweets. Several coders had previously conducted similar analyses in previous studies.

After training, coders identified initial themes that emerged using open coding. The emergent categories were discussed with the full team and a final list of themes was identified. Within the main themes, sub-themes also emerged.

During the iterative coding process, the trained three-person coding team met regularly to discuss application of codes, refine themes and subthemes and achieve analyst triangulation [38]. With the unit of coding being each tweet, the coding team reached 0.90 inter-rater reliability (percentage agreement) for each theme and employed consensus coding strategies for ambiguous tweets. In total, 935 non-exclusive codes of themes and subthemes (see Appendix Table A1) were assigned to the sample of HIV-related tweets.

Results

A total of 36 sub-themes emerged among the 935 non-exclusive codes that the coding team generated through the iterative coding process. The 36 sub-themes were grouped into three overarching themes: 1) *othering*, 2) *politics and activism*, and 3) *risk and wellness* (i.e., behavior-related tweets). In this section, we examine the viral tweets and present findings on each major theme, referencing exemplar tweets. Table 1 shows the top tweets in the analysis. Table 2 includes exemplar tweets from the themes and major subthemes discussed. Exemplar tweets have been edited to reduce searchability and protect Twitter users' anonymity.

Table 1 Most retweeted tweets in study analyses

Top Retweeted Tweets	Categories	Themes	Favorites	Retweets
Weed is illegal but knowingly giving people HIV isn't. White ppl make the DUMBEST decisions [URL]*	Pro substance use, Political, Pro-shame/stigma	Othering	2962	2802
my dik only small if she has seen a lot of other ones and that makes her a hoe. thats her problem not mine	Gender norms, Female derogatory terms, Pro-shame/stigma, Multiple partners	Othering	267	190
Woke Woman: Knows you're only a beard & walking dik, she tells you this too. Probably prefers women. Only hits you up after 10 pm	Jokes, Stereotypes	Othering	260	119
Would y'all rather date someone who is HIV positive or date someone who capitalizes the first letter of every word when they type	Jokes, Pro-shame/stigma	Othering	85	54
People with AIDS say anything kause they Finna die anyway [URL]	Pro-shame/stigma	Othering	34	45
Bob burger not funny? I hope u finna get an STD. [URL]	Pro-shame/stigma, Other STIs	Othering	42	43
When Magic said Ingram was the only untouchable on his team I think it was his HIV acting up	Pro-shame/stigma, Jokes, Others or non-consensual status disclosure	Othering	21	41
I seen a status on Fb that said "$150 for an Eazy E costume? It better give me AIDS & a record deal" ???? wtf	Money, Other's or non-consensual status disclosure, Pro-shame/stigma	Othering	23	34
If your girl never argues with u your dick is wack or she's cheating. Trust me	Gender norms, Jokes, Cheating, Stereotypes	Othering	57	31
Can anybody recommend a good lube? Been using Tag body spray, but it gave me HPV	Health questions/answers, Other STIs	Othering	25	29

Table 2 Exemplar tweets of themes and subthemes

Domain/Theme	Illustrative Quotes
1. Othering	
Sexual identity	[male celebrity 1] is still fucking male butts and sucking dick in the same closet [male celebrity 2] gets his clothes from
	She digs girls but dabbles in dick every now and then. I'm convinced lmao
Pro-shame/stigma	People with HIV would say anything, since they will eventually die anyways
	HIV is not a death sentence for many anymore, but it requires expensive medicines. Why waste money on this queer disease?
	So much HIV in the headlines
Female derogatory terms	Sucking dick with condoms on? Classy hoes y'all lmfao
Jokes/insults	Bro if my son turns out to be gay it's cuz his mom, I know my cum got no gay in It" and "I got one less follower today. To AIDS probably
2. Politics and Activism	
Anti-stigma	HIV Education That Aims to Empower, Not Shame. [URL]
	NO SHAME ABOUT BEING HIV POSITIVE while I EDUCATE ABOUT HIV WITH CARE NOT FEAR #iknowAwareness #ikA
	As a trans woman living with HIV, I need people to know that I exist & have needs. #PositivelyTrans, #AGLM [URL]
Political	#ONAP @WhiteHouse: Show commitment to ending #violence against #women w/ #HIV; talk WITH us, not FOR us. #NWGHAAD #WithoutUs
Awareness	!!! Always remember that HIV thrives in silence! Talk about it! #HIVisnotacrime
	Women with #HIV are subjected to violent relationships out of intimidation of their status being used against them. [URL]
	For women with HIV, violence is more deadly than the virus. NO VIOLENCE Against Women Living with HIV. [URL]
	#StandUpToStigma, decriminalize #HIV, decriminalize #Sexwork
	#sexworkers can be supported by not being judged for surviving and not being forgotten when discussing #HIV #BodilyAutonomy
3. Risk and Wellness	
Risk behaviors	Raw Dog or no Dog
	There is a higher power Cuhz. A n**** Raw Dog Guru. Say a prayer for me??? [asterisks added by researchers to indicate a racial slur]
	All what bitches do is suck dick, get smoked out
Health/wellness promotion	Sex is better raw but safer if you use the condom
	Never have, never will. #bbbh #neg [URL]
Pro-substance use	I was trying to do a line off someone's dick

Characteristics of viral tweets

As demonstrated in Table 1, the top ten most retweeted messages in our cohort all reflected the theme of *othering*. This suggested a wider propagation of tweets with a negative message, particularly tweets using humor to stigmatize certain groups.

Qualitative findings

Othering

The largest category in our sample was *othering* tweets (38.35%, *n* = 181), which we defined as tweets that contained stigmatizing or discriminatory messages. According to Johnson et al. [39], othering is the process in which the mainstream group identifies those different from themselves or the mainstream, followed by reinforced or reproduced positions of domination and subordination. Groups that are "othered" are often referred to as "them" [39]. In a healthcare context, othering can happen to persons with health symptoms or conditions

attached to taboos and stigmas, e.g., HIV. In our study, othering tweets included codes of "pro-shame/stigma," "female derogatory terms," "jokes," "insults," "other's or non-consensual status disclosure" and "sexual identity." Tweets were coded for "sexual identity" if they mention a person's sexual identity including being gay, lesbian, bisexual, queer, and other identities. Among sexual identity-related discussions, tweets contained shame and stigmatizing messages when commenting on the sexuality of others. For example, "staying in the closet" as hiding one's sexuality was occasionally referenced and depicted in sexually explicit language. We also observed tweets mocking sexual minority women, which included jokes about women who are attracted to women but occasionally have sex with men.

Sexual identity-related tweets within our *othering* theme implied an intention of shame and stigmatization that connected sexual identity to HIV or portrayed commercial sex work and mental illness with a negative

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bias. One tweet claimed that HIV was a wasteful "queer disease": "*HIV is not a death sentence for many anymore, but it requires expensive medicines. Why waste money on this queer disease?*" Another user thought the media was overly focused on HIV-related topics, saying "*so much HIV in the headlines,*" suggesting an unwillingness to view content about HIV, which also contributes to stigmatization of individuals with HIV and individuals within the LGBTQIA + community.

We also categorized derogatory terms about women (e.g., "bitches," "pussies," "sluts"), as *othering* tweets, and at times as jokes and insults. Tweets with jokes sometimes included "lol" (i.e., "laughing out loud") and "lmao" ("laughing my a** out"). In comparison, we identified tweets as insults that used HIV, STIs, sexual identity, and sexual activity with the intent to harm others. However, we note that tweets coded as jokes and insults often overlapped, which indicate the possible subjective interpretation of tweets in this analysis. Both insults and jokes were found to be carriers of pro-shame and stigmatization messages. Among all 123 pro-shaming/stigmatizing tweets, 33 were concurrently coded as insults, and 27 were concurrently coded as jokes.

Politics and activism

Politics and activism tweets accounted for 34.75% ($n=164$) of tweets and constituted the second largest theme. Health activism, which is activism targeting a health agenda, implies challenges against the existing order and power dynamics that are perceived to negatively impact health outcomes or health communication efforts [40]. We characterized these tweets as promoting awareness and anti-stigma sentiments about HIV criminalization, sexual violence, LGBTQIA + rights, or women's rights. *Politics and activism* tweets contained messages that advocated against violence towards people living with HIV and criminalization of HIV, promoted collective organization against injustice, and called for governmental action.

One way in which *politics and activism* tweets support social justice is promoting anti-stigma messages, which combat stigma against individuals living with or placed at risk for HIV. For example, one tweet noted, "*[a male celebrity] Died, But HIV Stigma Lives [URL]*", highlighting the widespread lack of social awareness and understanding related to HIV/AIDS. Other examples implied the importance of public health education in spreading anti-stigma awareness (e.g., "*HIV Education That Aims to Empower, Not Shame [URL]*") and the need for fostering "human decency" in conversations on HIV (because "*All'll the rules of human decency can go right out the window when people are known to have HIV. #pwnspeaks*").

In addition to anti-stigma messages, *politics and activism* tweets also contained messages promoting *awareness* or arguing for equality and representation for people living with HIV, with occasional use of public health terms. For example, there was one mention of undetectable viral load, one of the core messages in HIV-related public education and promotion campaigns (i.e., undetectable=untransmittable [U=U]). Another tweet called for more open conversations about HIV: "*!!! Always remember that HIV thrives in silence! Talk about it! #HIVisnotacrime.*"

Apart from *awareness*, *political* and *women's rights* are also major codes contributing to the theme of *politics and activism*. For example, the code of *women's rights* had the largest co-presence with *awareness* and *political* codes at the tweet level. Around 3.81% tweets ($n=18$) in our sample simultaneously mentioned *women's rights* and *political* codes, while 4.24% tweets ($n=20$) simultaneously mentioned *women's rights* and *awareness* codes. In contrast with the *othering* tweets, we categorized messages focusing on women's rights and representation under the *politics and activism* theme as well. Some of these tweets advocated for ending violence against women living with HIV and were tagged with both the codes, *political* and *women's rights* (e.g., "*#ONAP @WhiteHouse: Show commitment to ending #violence against #women w/ #HIV; talk WITH us, not FOR us. #NWGHAAD #WithoutUs*"). Besides a large prevalence of tweets focused on decriminalization of HIV and ending violence against women living with HIV, some tweets extended this advocacy to decriminalizing sex work. Similarly, many tweets of this category used activism hashtags and included web links to external information to engage other users. See Table 2 for additional exemplar tweets.

Risk and wellness

The third theme, *risk and wellness*, included messages endorsing risk or health behaviors, and encompassed 29.24% ($n=138$) of tweets. Overall, there was a greater proportion of risk-endorsing only tweets (15.47%, $n=73$) than health-promoting only tweets (7.63%, $n=36$), with the remaining 6.14% ($n=29$) ambiguous tweets often reflecting both categories. Risk tweets discussed engagement in sexual risk behaviors (i.e., multiple partners, cheating, condomless sex, transactional sex, and concurrent substance use) and substance usage (i.e., alcohol, marijuana, and other drugs). When sex and substance use/abuse were mentioned in a tweet, it was coded for concurrent substance use. On the contrary, health-promoting codes were related to engaging in

safe sex practices such as PrEP, condom use, optimizing medication adherence, and STI testing.

Tweets about sexual risk behaviors discussed condomless sex and sometimes implied factors contributing to non-condom use. For example, the tweet "*Raw Dog or no Dog*" construed a perceived dilemma between having condomless sex and not having sex at all. In another tweet, "*There is a higher power Cuhz. A n***** Raw Dog Guru. Say a prayer for me???*" [asterisks added by researchers to indicate a racial slur], the user brags about having condomless sex, while acknowledging the inherent risks. There was notably a Twitter hashtag, #bbbh (i.e., Bareback Brotherhood), which represents a community that endorses condomless sex. The hashtag was used in both pro-risk and anti-risk tweets. In terms of co-occurring substance use with sex, 3.18% ($n=15$) tweets mentioned substance use and desiring sex at the same time.

A small number (7.63%, $n=36$) of tweets from this sample focused on wellness and health promotion. These tweets discussed engaging in safe sex practices and healthy behavior, including discussions of PrEP (pre-exposure prophylaxis), PEP (post-exposure prophylaxis), condom use, achieving an undetectable viral load, medication adherence, and STI testing. Typical messages in this category included mentions of the health benefits of condom use.

Discussion

In today's social media spaces where information is abundant, and where content ranking algorithms are heavily influenced by the behaviors of both users themselves and their following networks, online browsing and engagement behaviors of youth can lead the algorithm to feature the "more popular" posts on more users' feeds, facilitating these posts to become viral. This relatively recent form of algorithm-moderated online interaction among youth enriched the context of Subrahmanyam et al.'s co-construction theory [23].

This study of viral tweets examined the discourse about HIV on Twitter among young men in the U.S. Through a qualitative content analysis, we identified three themes: (1) *othering*, (2) *politics and activism*, and (3) *risk and wellness*, garnering unique insight into the online discourse among young men that will inform digital health interventions. The tweets fell across a spectrum from promoting health behaviors and activism to promoting risk and stigma. Krueger and Young [8] similarly identified a diversity of tweets that contained both positive (e.g., anti-discrimination policy changes, messages of acceptance) and negative (e.g., anti-trans policies, body image issues) messaging.

We focused on tweets with more favorites and/or retweets, anticipating that they would have a higher amount of exposure and be more likely to have public health implications. *Othering* tweets, which included misinformation and stigma, received the most engagement. A study of HIV and other STI- related tweets noted that fear-related language, which includes stigma, was the strongest predictor of retweets, and were more often tweeted by individual users with anonymous accounts [41]. In this study, humor was the most common tool for reinforcing and propagating HIV-related stigma in tweets. These jokes are troubling as they function as sources of stigma and discrimination against women, sexual, gender, racial and ethnic minoritized groups and are regularly coupled with outright insults [9, 42, 43]. Gabarron et al. [41] also found that jokes were an effective mechanism for spreading discriminatory and ill-informed HIV-related messages. When viral tweets propagate misinformation or stigmatizing messages, there can be detrimental consequences for HIV prevention efforts [44]. Thus, studying these viral contents is of significance to identifying the potentially more influential yet problematic information, which is the first step to find targeted solutions to combat health misinformation and mitigate stigma.

Despite negative messages, this study corroborated previous research in finding that positive health messages are also shared on Twitter [41]. Health promoting tweets from individual users often included informative content and resources for HIV awareness and prevention. While most tweets focused on sexual risk behavior, there were other messages about specific HIV/STI prevention topics like PrEP. When people post factual health information from reputable resources to educate other users, these messages have the potential to increase prevention behaviors [29]. We also identified messages to raise awareness and political activism, some advocating for the rights and wellbeing of women, sex workers, and members of the LGBTQIA+community. This form of digital activism actively combats stigma through education, protest, and online community building; and confronts the structural drivers of HIV. Though this type of tweets did not receive the most engagement, which aligns with existing knowledge [45, 46], interactions among Twitter users can function to confront or contradict stereotypes and humanize stigmatized individuals [46].

Similarly, George et al. [47] observed that Twitter posts related to hashtag campaigns were more credible, albeit, less popular among Twitter users. Future digital health campaigns may appropriately incorporate design principles and communication strategies observed in viral messages to increase campaign impact. While

challenges exist to increasing engagement with positive health posts, there is potential to use social media to discuss the health and social needs of young men, sexual, and gender minorities.

Despite the negative discourse on Twitter, this platform is a useful medium for understanding attitudes and opinions in the public sphere. Our study supports previous research in highlighting Twitter as a significant public space for health and policy discourse [27]. Findings of our study, particularly those from the theme of *politics and activism*, may inform policy makers in pursuit of positive legislation change to promote social justice, including but not limited to increasing awareness, reducing stigma, eliminating HIV criminalization, controlling verbal violence, and protecting the rights of women, sex workers, and LGBTQIA+individuals. Meanwhile, Twitter data offers a unique opportunity to hear perspectives from adolescent and young adults about sex that they may be reticent to share in traditional surveys or interviews. Twitter is also a useful tool to promote HIV prevention behaviors, disseminate evidence-based information to communities, and advocate for sexual and gender minority wellbeing and acceptance through, for example, policy change.

This study also adds to the growing knowledge about how to best leverage online social networks to promote the pillars of the HIV prevention continuum (i.e., testing, condoms, and PrEP). For better or worse, Twitter has played a significant role in amplifying the public discourse around HIV-related issues, and much of this discourse includes stigma and misinformation. As mentioned above, HIV stigma was most often conveyed through jokes, which were highly retweeted and favorited, or of higher virality. Though not as viral, positive messages were still prominent in our sample. Regardless of positionality, messages on social media have the potential to shape or counter stereotypes about individuals at risk of or living with HIV. Twitter is an online environment where youth are affirmed and educated and/or stigmatized and misinformed. This process is not unidirectional but dialectical, as youth co-create, share, like and engage with sex and HIV related content in their online environment [23]. In the fight for the eradication of HIV and for health equity, we must engage with Twitter specifically, and social media platforms broadly, as key sources of health information, misinformation, and disinformation.

Limitations and future direction
This study has several limitations. We used NLP procedures to identify young male Twitter users based on language and user data. It is possible that some of the identified users in this sample were not male individuals,

as we did not recruit or verify individual users directly. Instead, our approach relied on gender and age prediction machine classifiers. Even though we attempted to limit bot accounts at the onset, our dataset still may contain some messages from Twitter bots or fake user accounts. Bot accounts have been found by previous research to propagate messages to polarize individuals during the U.S. presidential election cycle, promoting both left-wing and right-wing discourses on Twitter, with specific topics of vaccine safety and HIV infection and cure [48]. The political use of bots to weaponize HIV misinformation and disinformation on Twitter can pose a serious threat to the public's health by exacerbating HIV stigma, reducing support for HIV prevention and research efforts, dissuading the uptake of prevention behaviors and, by targeting minoritized communities, increasing long-standing health inequities.

We focused on the content of the viral tweets, operationalized as those that were favorited and retweeted the most among a larger sample pool of 24,600 HIV-related tweets. Extrapolation of findings should be made with caution. While our qualitative analysis allowed us to delve into these messages, we plan to work with HIV-related datasets of larger sample sizes and apply computational mixed methods in data analysis in future research. In addition to the number of favorites and retweets of a post, future research may also include the number of replies in the conceptualization of user engagement and analyze the content of replies.

While this study provides insight into youth's HIV discourse pertinent to a pre-pandemic period (2009—2017), the dataset presents limitations in recency. Future research may use our study as a comparator when studying temporal changes in how young social media users participate in online sexual discussions pre- and post-COVID-19. Meanwhile, a 2018 survey of the Pew Research Center reported that Twitter users are more educated and of higher incomes than the general U.S. population [49]; although their findings were not stratified by age groups yet age is often associated with incomes, the extent to which findings from this study about young male Twitter users can be extrapolated to contexts beyond Twitter should be considered in the light of data representativeness.

Conclusions
Our study of viral tweets provides insight into how young men talk about HIV and sex within their online communities. The content of these tweets is diverse, with themes of *othering, politics and activism*, and *risk and wellness*. Social media platforms like Twitter should be used to promote health and wellness messages, as harmful misinformation, disinformation, and messages that propagate stigma

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are prominent on the platform. Practitioners should have a plan to combat stigma, misinformation, and disinformation as a necessary component of any effective interventions online. Further, our findings suggest that the social acceptability of high-risk sex behaviors is high among young male Twitter users, and this population may benefit from targeted health communication intervention efforts.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s44247-024-00102-y.

> Supplementary Material 1.

Availability of data and materials
The dataset is not open sourced given the current uncertainty in Twitter's data policies which are still evolving. Access to deidentified data for noncommercial research purposes is available on a case-by-case basis upon request to the corresponding author, Yunwen Wang, PhD.

Declarations

Ethics approval and consent to participate
Not applicable; IRB determined as non-human subject research.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]University of Kansas, William Allen White School of Journalism and Mass Communications, Lawrence, KS, USA. [2]Cedars-Sinai Medical Center, Department of Computational Biomedicine, Los Angeles, CA, USA. [3]Northwestern Memorial Hospital, Chicago, IL, USA. [4]Weill Medical College, Cornell University, New York, NY, USA. [5]University of Southern California, Annenberg School for Communication and Journalism, Los Angeles, CA, USA. [6]School of Nursing, University of Pennsylvania, Philadelphia, PA, USA. [7]The Johns Hopkins University, Baltimore, MD, USA. [8]The Children's Hospital of Philadelphia, Philadelphia, PA, USA. [9]University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA, USA.

References
1. CDC. (2019). Basic Statistics | HIV Basics | HIV/AIDS. Retrieved October 27, 2021, from https://www.cdc.gov/hiv/basics/statistics.html.
2. Signorini A, Segre AM, Polgreen PM. The use of Twitter to track levels of disease activity and public concern in the U.S. during the influenza A H1N1 pandemic. PLOS ONE. 2011; 6(5): e19467. https://doi.org/10.1371/JOURNAL.PONE.0019467.
3. Stevens R, Gilliard-Matthews S, Dunaev J, Woods MK, Brawner BM. The digital hood: Social media use among youth in disadvantaged neighborhoods. New Media Soc. 2017;19(6):950–67. https://doi.org/10.1177/1461444815625941.
4. Vieno A, Massimo AE, Ae S, Pastore M, Douglas AE, Perkins D. Social support, sense of community in school, and self-efficacy as resources during early adolescence: an integrative model. Am J Community Psychol. 2007;39:177–90. https://doi.org/10.1007/s10464-007-9095-2.
5. Auxier B, Anderson M. (2021). Social media use in 2021. https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2021/04/PI_2021.04.07_Social-Media-Use_FINAL.pdf.
6. Algarin AB, Ward PJ, Christian WJ, Rudolph AE, Holloway IW, Young AM. Spatial distribution of partner-seeking men who have sex with men using geosocial networking apps: Epidemiologic study. J Med Internet Res. 2018;20(5):e9919. https://doi.org/10.2196/JMIR.9919.
7. Fernandez SB, Howard M, Hospital M, Morris SL, Wagner EF. Hispanic students' perceptions about HIV/STI testing and prevention: A mixed-methods study in a Hispanic-serving university. Health Promot Pract. 2018;20(5):742–50. https://doi.org/10.1177/1524839918801590.
8. Krueger EA, Young SD. Twitter: A novel tool for studying the health and social needs of transgender communities. JMIR Mental Health. 2015;2(2):e4113. https://doi.org/10.2196/MENTAL.4113.
9. Lohmann S, White BX, Zuo Z, Chan MS, Morales A, Li B, et al. HIV messaging on Twitter: An analysis of current practice and data-driven recommendations. AIDS. 2018;32(18):2799–805. https://doi.org/10.1097/QAD.0000000000002018.
10. Bobkowski PS, Brown JD, Neffa DR. Hit me up and we can get down. J Child Media. 2012;6(1):119–34. https://doi.org/10.1080/17482798.2011.633412.
11. Doornwaard SM, Moreno MA, van den Eijnden RJ, Vanwesenbeeck I, Ter Bogt TF. Young adolescents' sexual and romantic reference displays on Facebook. J Adolesc Health. 2014;55(4):535–41. https://doi.org/10.1016/J.JADOHEALTH.2014.04.002.
12. Moreno MA, Briner LR, Williams A, Brockman L, Walker L, Christakis DA. A content analysis of displayed alcohol references on a social networking web site. J Adolesc Health. 2010;47(2):168–75. https://doi.org/10.1016/J.JADOHEALTH.2010.01.001.
13. Moreno MA, Briner LR, Williams A, Walker L, Christakis DA. Real use or "real cool": Adolescents speak out about displayed alcohol references on social networking websites. J Adolesc Health. 2009;45(4):420–2. https://doi.org/10.1016/J.JADOHEALTH.2009.04.015.
14. Moreno MA, Parks MR, Zimmerman FJ, Brito TE, Christakis DA. Display of health risk behaviors on MySpace by adolescents: Prevalence and associations. Arch Pediatr Adolesc Med. 2009;163(1):27–34. https://doi.org/10.1001/ARCHPEDIATRICS.2008.528.
15. Shi J, Poorisat T, Salmon CT. The use of social networking sites (SNSs) in health communication campaigns: Review and recommendations. Health Commun. 2018;33(1):49–56. https://doi.org/10.1080/10410236.2016.1242035.
16. Patel VV, Ginsburg Z, Golub SA, Horvath KJ, Rios N, Mayer KH, et al. Empowering with PrEP (E-PrEP), a peer-led social media–based intervention to facilitate HIV preexposure prophylaxis adoption among young Black and Latinx gay and bisexual men: Protocol for a cluster randomized controlled trial. JMIR Research Protocols. 2018;7(8):e11375. https://doi.org/10.2196/11375.
17. Liu X, Lu J, Wang H. When health information meets social media: Exploring virality on Sina Weibo. Health Commun. 2017;32(10):1252–60. https://doi.org/10.1080/10410236.2016.1217454.
18. Alhabash S, McAlister AR. Redefining virality in less broad strokes: Predicting viral behavioral intentions from motivations and uses of Facebook and Twitter. New Media Soc. 2015;17:1317–39. https://doi.org/10.1177/1461444814523726.
19. Stevens R, Bonett S, Kenyatta K, Chittamuru D, Bleakley A, Xu JJ, et al. On sex, drugs, and alcohol: A mixed-method analysis of youth posts on social media in the United States. Journal of Children and Media. 2022; 0(0), 1–18. https://doi.org/10.1080/17482798.2022.2059537.
20. Zhang L, Jung EH. WeChatting for health: An examination of the relationship between motivations and active engagement. Health Commun. 2019;34(14):1764–74. https://doi.org/10.1080/10410236.2018.1536942.

21. Jain P, Zaher Z, Mazid I. Opioids on Twitter: A content analysis of conversations regarding prescription drugs on social media and implications for message design. J Health Commun. 2020;25(1):74–81. https://doi.org/10.1080/10810730.2019.1707911.

22. Fox S. The social life of health information, 2011. Pew Research Center Internet & American Life Project. 2011. https://www.pewresearch.org/2011/05/12/the-social-life-of-health-information-2011/.

23. Subrahmanyam K, Smahel D, Greenfield P. Connecting developmental constructions to the Internet: Identity presentation and sexual exploration in online teen chat rooms. Dev Psychol. 2006;42(3):395–406. https://doi.org/10.1037/0012-1649.42.3.395.

24. Steele JR, Brown JD. Adolescent room culture: Studying media in the context of everyday life. J Youth Adolesc. 1995;24(5):551. https://doi.org/10.1007/BF01537056.

25. Young SD, Jordan AH. The influence of social networking photos on social norms and sexual health behaviors. Cyberpsychol Behav Soc Netw. 2013;16(4):243–7. https://doi.org/10.1089/CYBER.2012.0080.

26. Vannucci A, Simpson EG, Gagnon S, Ohannessian CMC. Social media use and risky behaviors in adolescents: A meta-analysis. J Adolesc. 2020;79:258–74. https://doi.org/10.1016/J.ADOLESCENCE.2020.01.014.

27. Conway M. Ethical issues in using Twitter for public health surveillance and research: Developing a taxonomy of ethical concepts from the research literature. J Med Internet Res. 2014;16(12):e3617. https://doi.org/10.2196/JMIR.3617.

28. DeHaan S, Kuper LE, Magee JC, Bigelow L, Mustanski BS. The interplay between online and offline explorations of identity, relationships, and sex: A mixed-methods study with LGBT youth. J Sex Res. 2013;50(5):421–34. https://doi.org/10.1080/00224499.2012.661489.

29. Krueger EA, Chiu CJ, Menacho LA, Young SD. HIV testing among social media-using Peruvian men who have sex with men: Correlates and social context. AIDS Care. 2016;28(10):1301–5. https://doi.org/10.1080/09540121.2016.1178699.

30. Stevens R, Bonett S, Bannon J, Chittamuru D, Slaff B, Browne SK et al. Association between HIV-related tweets and HIV incidence in the United States: Infodemiology study. J Med Internet Res. 2020;22(6):e17196. https://doi.org/10.2196/17196.

31. Boudewyns V, Himelboim I, Hansen DL, Southwell BG. Stigma's effect on social interaction and social media activity. J Health Commun. 2015;20(11):1337–45. https://doi.org/10.1080/10810730.2015.1018604.

32. Zappavigna M. Ambient affiliation: A linguistic perspective on Twitter. New Media Soc. 2011;13(5):788–806. https://doi.org/10.1177/1461444810385097.

33. Sap M, Park G, Eichstaedt JC, Kern ML, Stillwell D, Kosinski M, et al. Developing age and gender predictive lexica over social media. In Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP). Doha, Qatar: Association for Computational Linguistics; 2014.

34. Lui M, Baldwin T. langid.py: An off-the-shelf language identification tool. Proceedings of the 50th Annual Meeting of the Association for Computational Linguistics. Association for Computational Linguistics. 2012; p. 25–30. https://aclanthology.org/P12-3005.pdf.

35. Schwartz AH, Giorgi S, Sap M, Crutchley P, Eichstaedt JC, Ungar L. DLATK: Differential language analysis ToolKit. In Proceedings of the 2017 EMNLP System Demonstrations. 2017; pp. 55–60. Association for Computational Linguistics. http://github.com/dlatk/.

36. Linvill DL, Boatwright BC, Grant WJ, Warren PL. "THE RUSSIANS ARE HACKING MY BRAIN!" investigating Russia's internet research agency Twitter tactics during the 2016 United States presidential campaign. Comput Hum Behav. 2019;99:292–300. https://doi.org/10.1016/j.chb.2019.05.027.

37. Wadhwa V, Latimer E, Chatterjee K, McCarty J, Fitzgerald RT. Maximizing the Tweet engagement rate in academia: Analysis of the AJNR Twitter feed. Am J Neuroradiol. 2017;38(10):1866–8. https://doi.org/10.3174/AJNR.A5283.

38. Corbin J, Strauss A. Basics of qualitative research: Techniques and procedures for developing grounded theory. Thousand Oaks: Sage Publications; 2014.

39. Johnson JL, Bottorff JL, Browne AJ, Grewal S, Hilton BA, Clarke H. Othering and being othered in the context of health care services. Health Commun. 2004;16(2):255–71. https://doi.org/10.1207/S15327027HC1602_7.

40. Zoller HM. Health activism: Communication theory and action for social change. Commun Theory. 2005;15(4):341–64. https://doi.org/10.1111/j.1468-2885.2005.tb00339.x.

41. Gabarron E, Serrano JA, Wynn R, Lau AY. Tweet content related to sexually transmitted diseases: No joking matter. J Med Internet Res. 2014;16(10):e3259. https://doi.org/10.2196/JMIR.3259.

42. Jewell LM, Morrison MA. "But there's a million jokes about everybody …": Prevalence of, and reasons for, directing negative behaviors toward gay men on a Canadian university campus. J Interpers Violence. 2010;25(11):2094–112. https://doi.org/10.1177/0886260509354499.

43. Lee S, Waters SF. Asians and Asian Americans' experiences of racial discrimination during the COVID-19 pandemic: Impacts on health outcomes and the buffering role of social support. Stigma and Health. 2021;6(1):70–8. https://doi.org/10.1037/SAH0000275.

44. McLaughlin ML, Hou J, Meng J, Hu CW, An Z, Park M, Nam Y. Propagation of information about preexposure prophylaxis (PrEP) for HIV prevention through Twitter. Health Commun. 2016;31(8):998–1007. https://doi.org/10.1080/10410236.2015.1027033.

45. Al Ramiah A, Hewstone M. Intergroup contact as a tool for reducing, resolving, and preventing intergroup conflict: Evidence, limitations, and potential. Am Psychol. 2013;68(7):527–42. https://doi.org/10.1037/A0032603.

46. Betton V, Borschmann R, Docherty M, Coleman S, Brown M, Henderson C. The role of social media in reducing stigma and discrimination. Br J Psychiatry. 2015;206(6):443–4. https://doi.org/10.1192/BJP.BP.114.152835.

47. George N, Britto DR, Krishnan V, Dass LM, Prasant HA, Aravindhan V. Assessment of hashtag (#) campaigns aimed at health awareness in social media. Journal of Education and Health Promotion. 2018;7:114. https://doi.org/10.4103/JEHP.JEHP_37_18.

48. Broniatowski DA, Quinn SC, Dredze M, Jamison AM. Vaccine communication as weaponized identity politics. Am J Public Health. 2020;110(5):617–8. https://doi.org/10.2105/AJPH.2020.305616.

49. Wojcik S, Hughes A. Sizing up Twitter users. Pew Research Center. 2019;24:1–23. https://www.pewresearch.org/internet/2019/04/24/sizing-up-twitter-users/.

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