RESEARCH ARTICLE

Investigating Public Discourses Around Gender and COVID-19: a Social Media Analysis of Twitter Data

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Abstract

We collected over 50 million tweets referencing COVID-19 to understand the public's gendered discourses and concerns during the pandemic. We filtered the tweets based on English language and among three gender categories: men, women, and sexual and gender minorities. We used a mixed-method approach that included topic modelling, sentiment analysis, and text mining extraction procedures including words' mapping, proximity plots, top hashtags and mentions, and most retweeted posts. Our findings show stark differences among the different genders. In relation to women, we found a salient discussion on the risks of domestic violence due to the lockdown especially towards women and girls, while emphasizing financial challenges. The public discourses around SGM mostly revolved around blood donation concerns, which is a reminder of the discrimination against some of these communities during the early days of the HIV/AIDS epidemic. Finally, the discourses around men were focused on the high death rates and the sentiment analysis results showed more negative tweets than among the other genders. The study concludes that Twitter influencers can drive major online discussions which can be useful in addressing communication needs during pandemics.

Keywords COVID-19 · Gender · Twitter · Social media · Public discourses

1 Introduction

The COVID-19 pandemic is likely to widen the gender inequality gap in health, healthcare access, social support, and livelihoods to an unprecedented level globally [80]. Gendered inequities increase both vulnerability and infection, as well as exacerbate the potential social and economic effects of an outbreak response [73, 83]. Cultural

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and social values, as well as political and economic structures, also influence who has access to educational and financial opportunities. In addition, a number of health-related issues such as sexual and reproductive health, gender-based domestic violence, and clinical trials for treatment are affected by gender inequalities, power relations, and socioeconomic differences [70, 73].

In the context of COVID-19, differences in the vulnerability to and mortality from the disease between males and females have led to important sex-based analyses, while gender analysis explores behaviors through social processes and norms [14]. Gender refers to different norms, roles, and relations related to what it means to be a man or a woman (as well as the consequences of not fitting into this binary) in a particular society. It is socially constructed and context-specific. Gender norms influence those who face greater exposure to infectious agents outside the home, who take the responsibility for caring for the sick, who face unmet healthcare services, and so forth [83]. As public health measures are implemented to combat the spread of the virus, it is important to understand how women, men, and sexual and gender minorities (SGM) may experience the COVID-19 response differently [29]. One way to better understand these differences is through analysis of online public discourses though this comes with its own limitations. For example, we could not determine the geographical location of users, and it is not easy to identify the users' genders unless they self-proclaim which does not frequently happen. As a result, our study focuses on the public discussions around different genders to ensure validity.

We also recognize the limitation of grouping a wide range of people within the SGM category. SGM is a broad term that includes individuals with a wide range of sexual orientations, gender identities and expressions, as well as physical characteristics [11]. This term was used by the National Institutes of Health (NIH) in 2015 as NIH announced the establishment of the Sexual and Gender Minority Research Office (SGMRO). As defined by NIH [50]:

> SGM is an umbrella term that encompasses lesbian, gay, bisexual, and transgender (LGBT) people, as well as those whose sexual orientation and/or gender identity varies, those who may not self-identify as LGBT (e.g., Queer, Questioning, TwoSpirit, Asexual, men who have sex with men [MSM], Gender-variant), or those who have a specific medical condition affecting reproductive development (e.g., individuals with differences or disorders of sex development (DSD), who sometimes identify as intersex). (p.1)

Indeed, SGM refers to a diverse and multifaceted population that is inclusive of those individuals who may not want to self-identify as one of the LGBT members or whose reproductive development is considered outside physiological norms. However, the language and terminology of SGM expression are dynamic and evolving [44]. It is also important to note that not all SGM groups are treated similarly or equally, and that inequalities and discrimination may exist within as well as towards this broad category.

The unprecedented speed and magnitude of the spread of the COVID-19 pandemic have led to increased social media activities as people turned to social media to acquire and exchange information [42]. For more than a decade, social media has been acknowledged as an important source of data for public health surveillance for emerging infectious diseases [41]. However, there is less recognition of the potential of social

media as a "surveillance" tool to identify emerging discourses, and their sources, during health crises. This is despite a growing recognition of the need to understand not only material experiences of health, but also the ideas and ideologies that shape them and are used to understand events like an outbreak [86]. In particular, there has been a lack of gender analysis of social media content that focuses on how people understand outbreaks. This inhibits public health communication interventions, which increasing evidence indicates must take gender norms and roles into account if it is to be effective [71]. Identifying social media discourses related to COVID-19, and analyzing them from a gendered perspective, provides a unique in-depth understanding of experiences and understandings of the pandemic, which can inform public health communications and interventions.

Specifically, this research identifies the main gendered trends on Twitter during the COVID-19 outbreak by conducting social media analysis through a gender lens, in order to assess discourses around gender and COVID-19. We were curious about existing concerns around issues related to women during the outbreak and whether there were any expressed socioeconomic risks or threats due to the pandemic among different gender groups. From a public health perspective, this research illuminates the gendered discourses, defined here as discussions shaped by and referencing different genders that reflect experiences of an outbreak, which in turn can inform measures to address resulting inequalities.

With advanced research on social media, it is possible to examine how different gender groups are discussed within the context of epidemics. Indeed, a better understanding of gendered concerns over specific infectious diseases helps guide researchers and policymakers in providing a more comprehensive response to address inequities.

1.1 Literature Review

There is no doubt that public discourses on social media about the COVID-19 pandemic are of great importance in current social media and COVID-19 studies. Our study offers important insight into the gendered discussions of the current COVID-19 pandemic. Earlier studies on social media and epidemics mainly covered the following three research areas: (1) examining the accuracy of medical information shared on social media platforms; (2) assessing the public's interest and responses; and (3) understanding organizations' use of social media and public responses [74].

In the first category, many studies focused on examining the accuracy of medical content on YouTube. Through content analysis, these studies tried to establish the relations between content characteristics and popularity of videos [25, 53, 55]. One of the most researched areas in this first category is the spread of disinformation on social media around the issue of COIVD-19 because conspiracy beliefs inhibit the implementation of appropriate health-protective measures and behaviors [4]. Concerns over the spread of misinformation on social media were mentioned by the World Health Organization (WHO) that termed the global epidemic of misinformation as the 'infodemic' [87]. An infoveillance study conducted by Abd-Alrazaq et al. [1] identified twelve topics under four main themes being shared on Twitter from February 2 to March 15, 2020: (1) origin of the COVID-19 virus, (2) sources of the novel virus, (3) the impact of COVID-19 on people and countries, and (4) methods for decreasing the spread of COVID-19.

Social media played a significant role in contributing to the spread of stigma, fear, disinformation, and conspiracy theories. For example, the rise in tweets mentioning "Chinese virus" or "China virus" after the US presidential reference of this term on March 16, 2020, indicated that COVID-19 stigma was likely being perpetuated on Twitter [13]. Cinelli et al. [19] mentioned that information disseminated from questionable sources was actively spreading on social media platforms such as Twitter, Instagram, YouTube, Reddit, and Gab. For example, the findings from an online survey study conducted on Instagram, Twitter, and WhatsApp suggested that key knowledge deficiencies pertaining to vaccination against COVID-19 existed [3]. Further, Allington et al. [4] explored the relationships of social media use, conspiracy beliefs, and health-protective behaviors in their online survey studies. Their results showed that social media acted as an important vector for the transmission of conspiracy beliefs. In terms of how to combat this infodemic, Pennycook et al. [57] examined the reason of misinformation sharing behaviors through online survey studies.

The second category consisted of studies that often used topic modelling analysis and sentiment analysis methods to track public discourses and concerns during epidemics (e.g., [18, 47, 69, 75]). Several other studies showed that governments and public health officials need to monitor social media trends and develop effective and empathic communication strategies to better address public concerns during the pandemic [43, 61, 79].

Based on theories of risk communication, the last category deals with studies that mainly assessed how organizations have used social media to communicate epidemics to their different stakeholders [24, 82]. The available studies on the role of social media during the COVID-19 pandemic to date have explored topics such as digital disease detection[1] and online health education [9, 10, 36, 45]. In the following section, a more detailed discussion is provided on gender and social media research on health.

1.2 Gender and Social Media Research

Women and minority populations suffered from gender discrimination within social media discourses and were underrepresented in public health debates [46]. However, prior work has identified the possibility of utilizing social media to support underrepresented gender and sexual minorities in medicine [51], since gender differences in social media use and influence among health researchers still existed [89]. Male health researchers, for example, had substantially greater influence in Twitter compared with their female peers ([89], p.1728). Discussions around gender diversity and inclusion in health have gained public attention on Twitter via commonly used hashtags such as "WomenInMedicine," "BlackMenInMedicine," and "QuoteHer," among others [46].

The effective use of social media has become a new priority for studying health-related behaviors, and previous studies highlighted the different social media uses between men and women. Rosenberg et al. [63], for example, examined gender differences in health participation on social media, while the influence of social media involvement on people's health-related behaviors has also been examined. For

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[1] Digital disease detection can be understood as using data mining techniques within social networks to track and predict the spread of the pandemic outbreak.

example, Park et al. [54] found that regarding SGM, social media involvement did not seem to have an impact on their sources of health information.

The nature of social media platforms makes socializing and online sharing visible to a great wider audience easier; therefore, existing social norms and concerns tend to be magnified on these online platforms [40]. Through a gendered lens, public health and social media research has focused on examining how gender stereotypes were presented in health-related content on social media platforms. LeBeau et al. [38], for example, studied how health-related content was discussed differently among men-focused vs. women-focused Snapchat Discover channels.

Another aspect of social media research and public health is related to studies on body image and wellbeing among genders. For example, previous researchers have focused on the effects of social media-delivered interventions on both weight management and body image concerns among different gender groups [26, 30]. Especially on image-centric platforms (e.g., Instagram), studies suggested that the impact of social media on body image among young women was mostly detrimental, causing problems of body dissatisfaction and eating disorder symptoms [26]. Griffiths et al. [30] found a correlation between social media use and body dissatisfaction among young girls and nonheterosexual men. The findings of the study indicated strong relationships between social media use and masculinity dissatisfaction among sexual minority men. Two other studies examined how traditional gender-role ideologies (e.g., hypermasculinity and hyperfemininity) were abundant on social media [15] and how the prevalence of traditional social norms around teen pregnancy on social media might stigmatize young women and cause harm to their general health [8].

There is no doubt that social media brought rapid changes to the health communication domain, and the rich user-generated health data provided by social media platforms offered useful sources for scholars to understand sexual and gender minorities' mental health needs. In connection to the effect of the pandemic on online communication, COVID-19 has changed how and what individuals self-disclose on social media [49]. Self-disclosure refers to communicating information about the self to another person [34]. Private and sensitive personal health information is shared more readily on social media in the name of public good. Nabity-Grover et al. [49], for example, found that there was a sense of public responsibility among individuals to share their personal COVID-19 diagnosis with others in the community on social media platforms under the mantra "we are all in this together." Existing literature shows a particular concern over mental health issues of sexual and gender minorities [31]. For example, Haimson [31] conducted sentiment analysis on Tumblr transition blogs (social media spaces for transgender people to document their gender transitions) to understand sentiment patterns during gender transition. In another social media analysis, Zhao et al. [88] found that sexual and gender minorities tended to express more negative feelings in their tweets compared with other gender groups on Twitter, which implied mental health-related concerns. For sexual minority youth (gay, lesbian, bisexual, sexually queer or fluid, or otherwise do not identify as heterosexual), their use of social media particularly for sexual identity development predicted positive impacts on their mental health [17, 32].

Further, social media provide a special "lens" to examine gender and cultural differences in how people express their thoughts and concerns over illness and health [22]. In a sentiment study on the differences of how men and women stroke survivors expressed their feelings on Twitter, Garcia-Rudolph et al. [28] concluded that women

expressed positive emotions and happiness much more than men. Gender differences were also found in another study on examining how mental illness and therapy are perceived. Using semi-supervised learning, De Choudhury et al. [22] identified individual users who self-disclosed to have an underlying mental health issue on Twitter. Their results showed that males expressed higher negativity and lower desire for social support, compared to females. In terms of infectious disease phobia, Jung et al. [37] studied the social and cultural determinants of disease phobia on bovine spongiform encephalopathy (BSE) and highly pathogenic avian influenza (HPAI). Their findings suggested women's risk perception was different from that of men's, for women showed more anxiety regarding BSE and HPAI, and they also had a higher level of risk perception of infectious diseases.

As for gender studies and the COVID-19 pandemic, they mostly focused on a diverse range of problems related to gender relations and differences. For example, Sevilla and Smith [67] explored the division of home labor and the underlying gender determinants of this specialization during the COVID-19 pandemic. Their results indicated that in terms of childcare labor, mothers bear the most part of the burden. The additional hours of childcare left women struggling between work and childcare, which might cause adverse effects on women's mental health and future careers [67]. Another study conducted by Collins et al. [20] in the USA investigated changes in mothers' and fathers' working hours from February to April 2020. Collins et al. [20] found that among dual-earner families, mothers had reduced work time significantly more than fathers, especially for those families with young children; mothers tended to take the majority of responsibility of childcare. The pandemic affected women more heavily than men not only in respect of working hours but also through drifting women's attentions away from work to childcare, exacerbating a future widening of the gender wage gap [21]. Also, gender differences were highlighted in studies that examined the impact of COVID-19 pandemic and its related quarantines on people's mental health situation. Ausín et al. [7], for example, found that the pandemic appeared to have a greater psychological impact on women than men. Women showed more symptoms of mental depression and anxiety and more feelings of loneliness when compared to men [7]. Regarding conspiracy beliefs, Cassese et al. [16] suggested that women were significantly less likely to support conspiracy theories that men and this gender gap transcended party lines.

Historically, in terms of public health surveillance, there has been a lack of reliable data on SGM populations which rendered the physical and mental health needs of SGM populations largely unknown to the public [56]. An online cross-sectional survey study found that SGM populations had a significantly higher proportion of depression and anxiety levels exceeding the clinical concern threshold [48]. Similarly, a comparison study conducted by Rodriguez-Seijas et al. [62] suggested that SGM populations experienced higher prevalence of various types of psychosocial dysfunction compared with cisgender heterosexual people. Phillips II et al. [58] called on public health practitioners to amplify the voices of SGM communities. During the COVID-19 pandemic and its induced quarantine orders, SGM adolescents also might face loneliness, negative mental influences, and family rejections. In light of these concerns, Salerno et al. [65] argued that public health stakeholders must pay attention to the mental health threats faced by SGM young people, and DeMulder et al. [23] advocated that more work needs to be done to increase access to LGBTQ-affirming resources to address the needs of SGM adolescents.

The above studies clearly show the potential of social media as a useful way to examine and study gender dimensions of health and illness. In our survey of the existing academic literature, we found a clear gap in studies on health crises and social media research that takes a gendered perspective. One recent study conducted that using online questionnaires highlighted the importance of gender in understanding anxiety and depression during COVID-19 in the Turkish society [52]. While at the time of writing this study, there was not one peer-reviewed published study on social media data referencing COVID-19 and gender.[2] Our study attempts to answer the following research question: What are the differences in the gendered public discourses on COVID-19 on Twitter?

2 Methods

This study aims to fill this identified gap in the literature by investigating gendered public discourses around COVID-19 on Twitter. We focused on Twitter because it allows the bulk collection of publicly available data unlike the majority of social media platforms, allowing us to identify patterns in the public discourses on different issues. We collected a total of 50,811,299 tweets posted between February 12 and April 18, 2020, and sent by 11,706,754 unique users. We only collected tweets and retweets as we believe that both of them provide important insight into the public discussions, patterns, and trends regarding the pandemic. This dataset was collected using the Twitter Collection and Analysis Toolkit (TCAT) platform that utilizes Twitter public API, allowing about 1% of public tweets to be fetched. Due to API limitations, the platform often hits the rate limit allowed so a brief delay sometimes happens in collecting tweets. The above time period was chosen because COVID-19 became a trending topic on Twitter in February, and we stopped in April due to the large size of the dataset as we believe we collected enough data to make general conclusions on gendered discussions of the pandemic.

In order to extract relevant English tweets related to gendered discourses, we used a Python 3 script to search for specific words related to different genders (i.e., women, men, and SGM). In relation to tweets referencing women, we used the following words: "woman*," "women," "femin*," "girl*," "lady," "ladies," and "female*." The total number of English language tweets referencing the above search terms was 541,698, constituting 1% of the total dataset of 50,811,299. These filtered tweets were sent by 367,037 unique users. In relation to references to men, we used the following search terms: "boy*," "man*," "men," "gentlem*," "mascul*." The total number of English language tweets referencing the above search terms is 297,155 sent by 231,899 unique users. As for SGM, we used the following words: "nonbinary," "non-binary," "trans,"

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[2] Though not yet peer reviewed, Thelwall and Thelwall [77] conducted a social media analysis on Twitter that focused on gender differences in topics and reactions to COVID-19. More than 3,000,000 English tweets about COVID-19 from March 10 to 23, 2020, were collected. In this study, a list of gendered first names was used to match the first part of Twitter display names to identify the gender of users [77]. The results presented that females are more likely to tweet about COVID-19 in the context of family, social distancing, and healthcare, whereas males are more likely to tweet about sports cancellations, the global spread of COVID-19 as well as political reactions. This study has many limitations such as its relatively small dataset, and it failed to include the public concerns of sexual and gender minorities as it discussed gender as a binary concept.

"transgender," "two spirited," "two-spirited," "LGBT*," "gay*," "homosexual*," "lesbian," "bisexual*," and "queer." A total of 26,048 tweets were extracted, constituting all the relevant English language tweets (Fig. 1).

We also used other Python 3 scripts to extract the most frequent words, hashtags, and mentions, while sentiment analysis was conducted using a Python 3 package called VADER [35] whose algorithm calculates the sentiment score of each tweet and measures the mean with values ranging between −1 and +1 (−1 highly negative, +1 highly positive, 0 neutral). Regarding topic modelling, we used QDA Miner–WordStat 8 that offers features like proximity plots, network word mapping, and a topic modelling tool that is built on factor
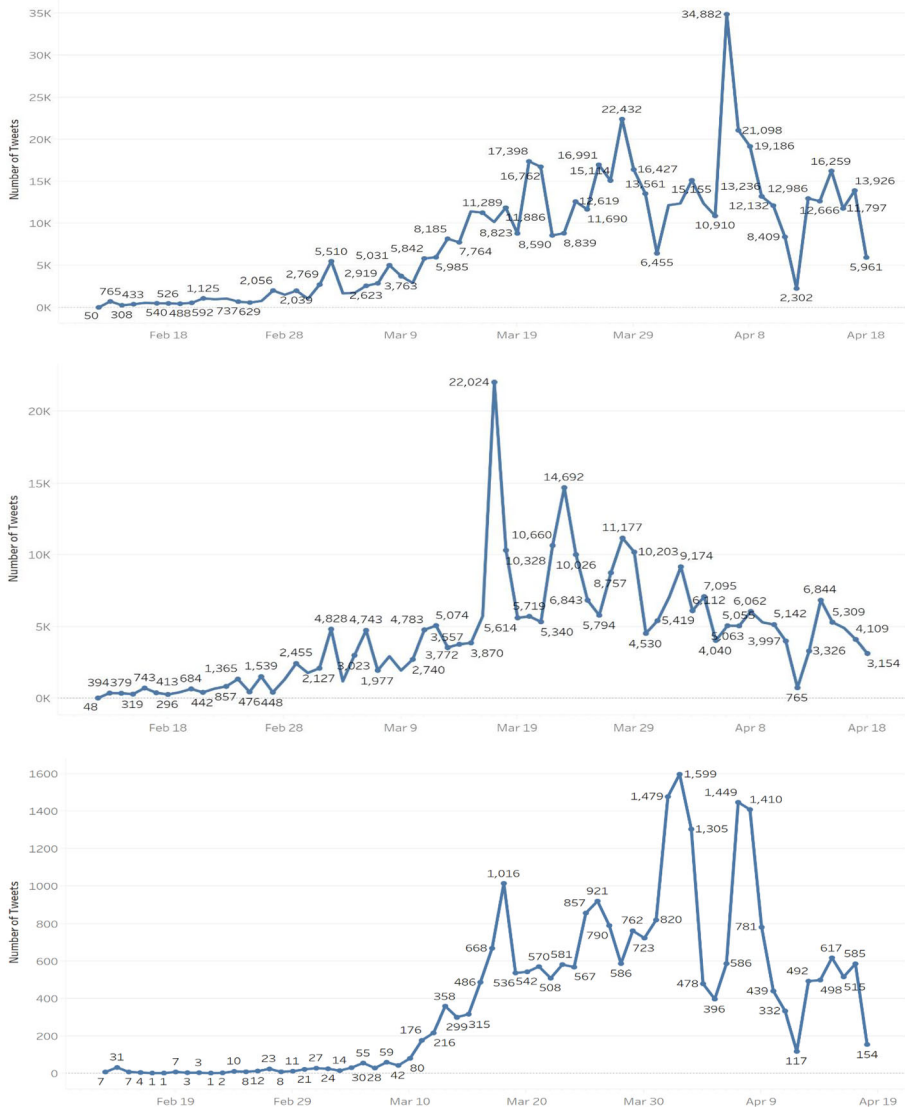

Fig. 1 Frequency of tweets referencing women (top), men (middle), and sexual/gender minorities (bottom)

analysis (FA). The FA approach ranks topics based on the Eigenvalue that is a mathematical linear system, indicating the dominance of certain topics in the text corpus, for the higher this value is, the more dominant the topic is found in the corpora ([5], p. 691). Both the sentiment analysis and topic modelling tools that we used did not require any pre-processing data procedures as they have them both built in. For example, when uploading the datasets into QDA, we used the "English.exc" option for the default exclusion list of words. The software has a built-in exclusion dictionary or what is known as stop list which is "used to remove all words" that have "little semantic value such as pronouns, conjunctions, etc." ([59], p. 27). For the textual pre-processing option in WordStat 8, we chose case sensitive option to differentiate between words with slightly different features like COVID19 and COVID-19. We did not choose the stemming or lemmatization options because they "may decrease the measurement precision of some concepts or topics" especially that numerous mistakes can occur, e.g., the stem "univers" might include conceptually different words like "universal," "universe," and "university" ([59], p. 27). As for the textual postprocessing option, we chose frequency of case occurrences higher than 30 and keeping a maximum of 300 items based on the TF*IDF category. We chose the latter option to ensure the software's "stability of the factoring solution," for "low frequency items should preferably be excluded" (p. 45) since the software has limitations in processing larger number of topics.

3 Results

Our study focused on the gendered discourses around COVID-19 and the differences among them. As can be seen in Fig. 1, the overall scale of discussions on COVID-19 referencing women, men, and SGM varied dramatically. There were 541,698 tweets referencing women, 297,155 tweets referencing men, and 26,048 tweets referencing sexual and gender minorities. Upon close examination of these line charts, we found that the highest number of tweets was reached on different dates for each gender group (women, April 6, $n=34,882$; men, March 17, $n=22,024$; and sexual and gender minorities, April 2, $n=1599$), mostly because of the role of Twitter influencers that will be discussed below.

3.1 Topic Modelling

As for the salience of topics, Table 1 shows the most recurrent topics in the three datasets, indicating clear differences among women, men, and SGM. For tweets referencing women, the prominent topics included "medical bills" ($\lambda= 9.15$), "Zithromax as an effective treatment" ($\lambda= 7.15$), "Republican Jim Jordan"[3] ($\lambda= 4.61$), "confirmed cases" ($\lambda= 3.89$), and "face violence under lockdown" ($\lambda= 2.83$). Twitter discussions referencing men revolved around the following topics: "easing

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[3] The US Republican Jim Jordan voted against the #COVID19 relief funding bill, and the third most retweeted post reads as follows: "RT @ShannonFreshour: Republican Jim Jordan voted against the #COVID19 relief bill. I need your help to defeat Jim Jordan. If you support a strong Democratic woman over Republican Jim Jordan, retweet this and join our fight to flip this seat" ($n=5541$).

Table 1 Topic modelling of gendered Twitter discourses ranked based on their eigenvalue

No.	Women	Eigenvalue	Men	Eigenvalue	Sexual/gender minorities	Eigenvalue
1.	Medical bills	9.15	Easing lockdown	24.02	Months of no sexual activity	16.02
2.	Zithromax as an effective treatment	7.15	Receiving treatment	15.99	Health Minister tests positive	4.75
3.	Republican Jim Jordan	4.61	Died after contracting	8.44	Ration support	3.67
4.	Confirmed cases	3.89	Penang	7.26	Transgender girls	3.18
5.	Face violence under lockdown	2.83	Insurance	6.08	AIDS crisis	1.88

lockdown" (λ= 24.02), "receiving treatment" (λ= 15.99), "died after contracting" (λ= 8.44), "Penang" (λ=7.26), and "insurance" (λ= 6.08) (Table 1). Finally, the salient topics referencing SGM include "months of no sexual activity" (λ=16.02), "Health Minister tests positive" (λ=4.75), "ration support" (λ=3.67), "Transgender girls" (λ=3.18), and "AIDS crisis" (λ=1.88).

3.2 Sentiment Analysis

Regarding our sentiment analysis results, we found that the overall sentiment scores of tweets referencing women and SGM were slightly positive (0.058405 for women, and 0.079799 for SGM), while the sentiment score of tweets on men was mildly negative (−0.0831).

4 Discussion

We first investigated differences in tweet frequencies among the three datasets, which is an indicator of the power of Twitter influencers. For example, the peak in relation to references of women was in response to Lady Gaga's WHO announcement on that day, retweeting a WHO message on the COVID-19 virtual press conference on April 6, 2020 [84]. Lady Gaga was also the top mentioned user in the women's category dataset (*n*=23,998). In addition, the collaboration between Lady Gaga[4] and the WHO to promote the "One World: Together at Home" concert was heatedly debated on Twitter. For example, Lady Gaga's slogans like "TogetherAtHome" (*n*=7805) and "CallforCode" (*n*=4717) were among the top hashtags (see Table 2). As for tweets on men, there was a reference to a song by the British male rapper, Pyschs, retweeted by @floeticmusic who was the most mentioned user in the dataset of the men's

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[4] Lady Gaga, a famous American female celebrity, made the late night talk show rounds on April 6, 2020 to promote a coronavirus effort: the Global Citizen/World Health Organization "One World: Together at Home" concert. Besides this effort, she has also been part of the 2020 IBM Call for Code Global Challenge, which IBM has already put $25 million behind developing top solutions. The initiative was supported by Global Partner UN Human Rights and the Linux Foundation.

Table 2 The top 20 most mentioned hashtags along the three genders

No.	Women	Count	Men	Count	Sexual/gender minorities	Count
1.	Covid19	545250	Covid19	294964	Covid19	25689
2.	Coronavirus	78158	Coronavirus	37278	Coronavirus	3800
3.	Covid	11594	Coronavirusuk	17116	LGBTQ	3154
4.	Covid19lagos	8114	Covid	10039	Gay	2163
5.	Togetherathome	7805	Stayhome	7492	LGBT	2015
6.	Stayhome	5679	Iran	4791	Covid	973
7.	Yogiroxx	5669	Coronavirusoutbreak	3745	Quarantine	788
8.	Up	5381	Coronaviruspandemic	3090	Trans	749
9.	Women	5217	Covid_19	2969	Socialdistancing	698
10.	Callforcode	4717	Coronavirusupdate	2657	TWGRP	682
11.	Iran	4468	China	2643	Mighty200	682
12.	Stayhomesavelives	4297	Coronavirususa	2622	Transgender	615
13.	China	4235	Breaking	2582	Tiktok	567
14.	Globalcitizens	4046	Stayathome	2222	HIV	533
15.	Plankthecurve	4044	Stayhomesavelives	2168	Fursuit	532
16.	Lockdown	3998	Lockdown	2161	Quarantineandchill	409
17.	Westkerry	3927	Coronaupdate	2072	Wednesdaymotivation	365
18.	Coronavirusoutbreak	3459	Covid-19	1928	Wednesdaythoughts	364
19.	Socialdistancing	3171	Pandemic	1818	Stayhome	291
20.	Cashappblessing	3151	NHS	1750	Teambottom	278

category (n=16,799). The message was also the most retweeted one in the men's category dataset.

As shown above, the role of the entertainment industry can be important in health communication during pandemic times. Both artists received a great deal of attention from their audiences who retweeted their messages that focused on raising awareness on many pressing issues like the importance of following health instructions and staying at home during the lockdown. This finding is in line with previous research on the effectiveness of entertainment-education (EE) during the times of health crises [60, 64, 66, 72]. Furthermore, the capacity of specific artists to reach different gender demographics should be taken into account, especially in relation to their fan base. Lady Gaga, for example, is well known for championing and promoting gender equality and the causes of and SGM, an issue that makes her possibly more influential among women as well as gender and sexual minorities.

Regarding the dataset of SGM, the peak occurred mostly due to retweeting AJ+, an Al Jazeera English affiliated digital news platform, which sent the following message: "@ajplus: BREAKING: The FDA updated blood donation rules for LGBTQ+ men, citing 'urgent' need for blood during the #COVID19 pandemic. Men can donate after 3 months of no sexual activity with another man, down from 12 months. https://t.co/XnQ4IXV2te." This channel's account, @ajplus, was also the most mentioned one in this dataset (n=1437), and it is another influential Twitter user that highlighted updated health guidelines about blood donation by MSM. Our findings correspond with

previous research on the role of Twitter influencers in initiating public debates and discussions [2, 6, 85]. In brief, the three Twitter accounts mentioned above are already famous, playing an important role in intensifying the public discussion about COVID-19. Though the way the information was communicated differed (tweets, song clip, and news report) among these influential users, they all communicated important health guidelines and updated news on the pandemic to their audiences.

4.1 Top Retweeted Posts

The investigation of the top 20 most retweeted posts in the women's dataset shows that most messages contained praise for women scientists and world leaders fighting the virus, while others expressed sympathy for the deceased. For instance, the following message was retweeted 2477 times: "RT @IasAlok: Meet Minal Dakhave Bhosale, the R&D Chief of Mylab. She led the team that designed India's first indigenous #COVID19 testing kit. Delivered the kit before delivering her baby. Who said women can't do well in #STEM. Do read this story. Inspirational! https://t.co/VmGq0WeOuV https://t.co/cLI3ul1quw." Only a couple of tweets contained some polarized political messages targeting political leaders such as the following one: "RT @AndrewPollackFL: Your daily reminder that… Nancy Pelosi told her constituents to CROWD into the streets while #COVID19 was spreading around the world. How does this woman have the nerve to blame @realDonaldTrump for the spread of the virus? https://t.co/n0J5lMAU70."[5] The same observation is found upon examining the top retweets in the datasets of men and SGM. For example, and similar to the top tweets on women, we found two tweets that contained political messages: one criticized Kamala Harris, US Democratic senator, while the other one mocked Boris Johnson, the UK's Prime Minister.

4.2 Gendered Concerns Related to COVID-19

Regarding the topic modelling analysis, we found that discussions around different gender groups revealed distinct concerns and worries about the COVID-19 outbreak (Table 1) which can be categorized as follows:

4.2.1 Concerns related to women

For tweets referencing women, several salient topics were observed. "Medical bills" was the topic that was tweeted the most. This topic may reflect public concerns in the USA about COVID-19's costly medical bills and the issue of relief funding bills. This could also be noted from the top mentions of "abbyabrams"[6] (n=12,778). Abigail Abrams, a journalist from TIME, covered a story about an uninsured woman COVID-

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[5] Another example is found in the second most retweeted post which indirectly attacks the climate change activist, Greta Thunberg, stating: "RT @DeAnna4Congress: 75% of doctors agree that Hydroxychloroquine & Zithromax are an effective treatment for #COVID19. The Media: UNPROVEN! FAKE! NOT BACKED BY SCIENCE! A sixteen year old girl from Sweden says the earth will end in ten years & we will all die. The Media: WE MUST LISTEN TO HER!" (n=10540).

[6] "abbyabrams" is Abigail Abrams's Twitter account username. She is a staff writer for TIME and mainly covers topics around healthcare policy and politics.

19 patient and her exorbitant medical bills. This story raised much attention and was intensely discussed on Twitter by many users. This issue ties back to the Twitter role of women influencers who can raise awareness about the pandemic since offline fame gives agency and power for some women to voice certain gendered concerns. As can be seen in Fig. 2, there is a small cluster of words in light green, such as "bills," "cost," and "uninsured" that are connected to "@abbyabrams."

Further, our results also indicated that domestic violence was another major concern surrounding public discourses referencing women. In fact, the word "violence" was repeatedly used 24,555 times, as COVID-19 infection control measures such as social distancing and home quarantine potentially put women and girls under the threat of domestic violence [81]. This was reflected in the fifth most retweeted post, originally sent by the Secretary-General of the United Nations, António Guterres.[7] When examining the proximity plot of the word "girls," we found further evidence that corroborates the above arguments, for the word "violence" is strongly associated with it, followed by "crisis" (see Fig. 3).

4.2.2 Concerns related to men

As for tweets referencing men, the most salient topic was related to "easing lockdown," indicating public discourses around the need to ease or lift the lockdown. It was mostly used as a call for going back to normal living, which was partly attributed to the psychological toll and social impact of the pandemic. To further corroborate the above, we found that the second most retweeted post (n=11,001) mentioned a man who tested positive for COVID-19 but refused to self-quarantine and instead went shopping at Walmart.[8] We can also see from the network word mapping in Fig. 2 that there was a cluster of words such as "tested," "quarantine," "dangerous," "emergency," "refused," and "Walmart" which mostly referred to this particular instance. Though it is linked to risky behavior, the "easing lockdown" topic was also associated with the financial burdens of staying at home and medical "insurance," expressing concerns about the potential cost of medical treatment.

The topic "died after contracting" was also prominent, highlighting the disparity in the number of deaths among the genders, as men are more likely than women to die after contracting the virus [76]. Moreover, words such as tested "positive" (n=44865), "died" (n=31,719), and "death" (n=24,130) were among the top 20 most frequent words referencing men (Fig. 2), and such words were missing among the top mentions in the two other datasets.

Further, the majority of the top 20 most retweeted posts reference the high number of casualties among men, often praising recovered patients and expressing sympathy

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[7] The tweet states: "RT @antonioguterres: Peace is not just the absence of war. Many women under lockdown for #COVID19 face violence where they should be safest: in their own homes. Today I appeal for peace in homes around the world. I urge all governments to put women's safety first as they respond to the pandemic. https://t.co/PjDUTrMb9v" (n=4897). Indeed, Guterres is another Twitter influencer whose views attracted the attention of the Twitter public.

[8] The original tweet reads: RT @w_terrence: 📟 📟 911 EMERGENCY TWEET 📟 📟 A man who tested positive for #COVID19 refused to self quarantine & then went to Walmart He said "If I got it y'all gone get it too, F - all y'all." He is dangerous ***PLEASE 2 RETWEET*** We must find out who this guy is https://t.co/jAqAGShFzu.

Fig. 2 A network word mapping of the most recurrent words and their associations for women (top), men (middle), and sexual/gender minorities (bottom)

for the deceased.[9] Some of the top retweets also contained health advice for men, such as the following tweet: "RT @joeyrooster: My wife has #COVID19 #NHS midwife (no PPE provided)…..This thing has literally floored her. We have 3 small boys. I have never been so scared in my life. Dont be a dick. Stay in & if u have to go out, practice social distancing. #StayHomeSaveLives" (n=1328).

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[9] The third most retweeted post was originally sent by the Malaysian Ministry of Health, which is another influential user, and mentions the following: "RT @KKMPutrajaya: #COVID19 disease has spread all over Malaysia and killed two local men so far. Currently, 622 patients are receiving treatment in hospital with 12 in intensive care unit. Malaysians, please distance yourselves from crowded places to prevent infections. #StayHome https://t.co/eddQOaM9bD" (n=5306).
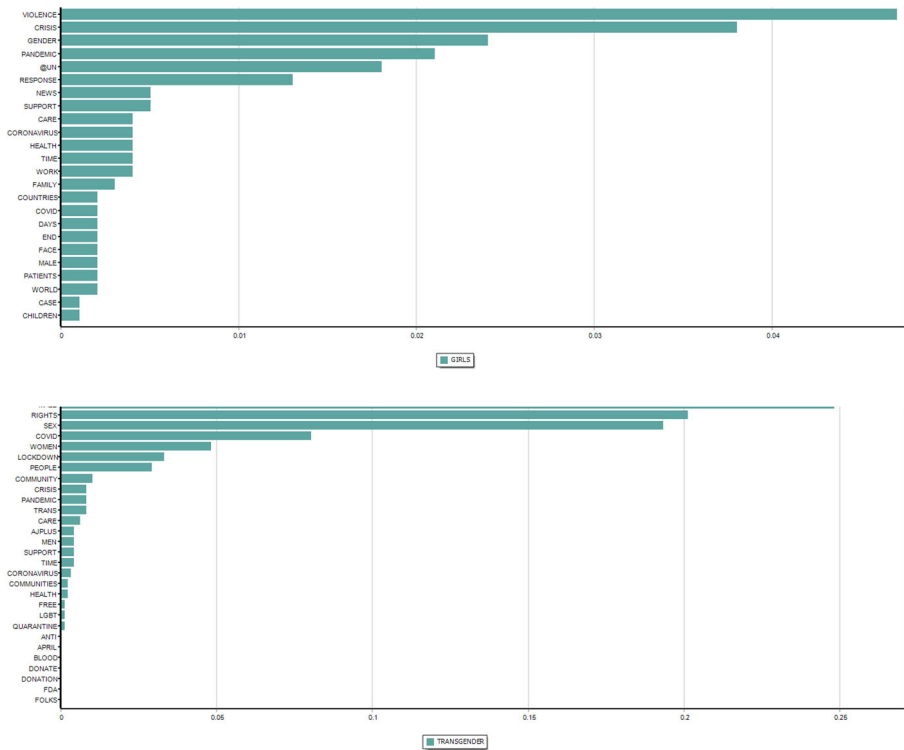
Fig. 3 The proximity plot of the words "girls" and "transgender"

Finally, the sentiment analysis of the study shows that men received the most negative sentiments (−0.0831) among the genders mostly due to tweets referencing the high number of deaths among this gender group.

4.2.3 Concerns related to SGM

The topic modelling analysis of the SGM dataset showed a specific concern over blood donation by MSM. This was reflected in the first topic on "months of no sexual activity" which is tied to the abovementioned @Ajplus' news report on regulations surrounding blood donation (Fig. 2). The other most tweeted topics were: "health minister tests positive," "ration support," "transgender girls are male." Interestingly, one of the top most tweeted topics was the "AIDS crisis," which is a reminder of the stigma MSM suffered during the 1980s and 1990s due to various misconceptions and misinformation [12]. To corroborate the above findings, we also found that the most frequent phrases in this dataset consisted of two words: "men donate" (n=1264) and "blood donation" (n=1247), while some of the top 20 most frequent words included "blood" (n=3346), "donate" (n=2260), and "rules" (n=1553). Additionally, the network word map and proximity plot results show a particularly dense cluster of similar words that indicated the salience of blood donation terms (Fig. 2), as well as concerns to protect the rights of this community including providing aid, rations, and other types of financial support (Fig. 3).

5 Conclusion

Our study investigates the gendered discourses around COVID-19, and we found clear differences in the salient topics discussed about women, men, and SGM. For example, medical bills and domestic violence issues were more prominently discussed around women, while easing the lockdown and the high death rates were very recurrent in discourses on men. Public discourses around SGM, however, focused mainly on blood donation concerns. From these discussions, we can see that each gender group faces different concerns and challenges in the time of the COVID-19 pandemic.

Informal family caregiving, particularly the care of parents, spouses, or other family members, places a significant burden and responsibility on those who care [39]. The social and cultural forces underlying the fact that the responsibility of family care falls most heavily on women further perpetuate this gender inequality [33]. The ongoing COVID-19 pandemic has intensified women's burden of caregiving as family members fall ill [81]. Moreover, together with this burden of family care, women also face greater concerns about surprise medical billing due to hospital triage protocols and staff shortages [68]. The risks of domestic violence due to the lockdown were another major concern surrounding discourses around women and girls, which remains a major public health challenge. Worldwide, women and girls suffer from increased risk and prevalence of gender-based violence, and efforts to reduce the spread of COVID-19, such as lockdown and quarantine, have increased women's vulnerability and marginalization [78].

While for SGM, the large discussion around blood donation revealed a long-existing debate over blood donation of MSM (men who have sex with men). Historically, MSM suffered from unjustified exclusion from blood donation. This exclusion has become a form of discrimination towards MSM which further led to social marginalization and stigmatization [27]. The urgent need for blood and blood components during the pandemic highlighted this concern. For MSM, blood donation is more than just a practice of individual altruism; rather, it also indicates a strong expression of social solidarity [27].

The study also found that Twitter influencers often initiate debates and discussions on important aspects of health communication. Some women influencers, for example, initiated lively discussions on COVID-19 and the concerns many women face during the lockdown. Through social media analysis, dominant discourses can be traced back to specific sources and, much like contract tracing of viruses, knowledge of these sources can be used to inform public health interventions. Influencers might be used to maximize the spread of health communications, and harmful discourses (such as those questioning the validity of public health recommendation) can be curtailed. As we have seen with discourses around vaccines, ideas and ideologies can be as important determining factor in public health interventions as accessibility and availability. This article presents an example of how public health discourses can be traced and analyzed through a gender lens. We believe that Twitter offers important insight into gendered public concerns and perceived risks, which can be useful in designing public health policies and campaigns.

However, our study is limited to Twitter and future studies should include other social media sites like Facebook and Instagram though it is difficult to get large datasets involving audiences' messages from them. Our study was also limited in terms of the

search terms used as other possible phrases or words could have been used such as "pregnant," "transsexual," "intersex," "asexual," "pansexual," etc. Also, we used a few digital methods here like sentiment analysis and topic modelling which are useful in processing large datasets, but they are not perfect approaches because both suffer from data reduction features especially due to their dictionary-based approaches. For example, topic modelling will only highlight the dominant topics rather than all the available topics, and sentiment analysis provides aggregate outcomes to make the data clearer to understand in terms of positive, negative, and neutral terms without proper contextualization. Also, the use of stop words limits the amount of processed data. As Murthy confirms, "imposing pre-ordained coding categories can limit our understanding not only of individual tweets, but also larger Twitter discourses…" (p. 563). To sum up, we believe there is a need to continue this line of gendered inquiry to understand other aspects of public discourses such as homeschooling, pregnancy, and childcare issues.

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