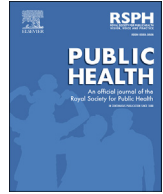Elsevier has created a [Monkeypox Information Center](#) in response to the declared public health emergency of international concern, with free information in English on the monkeypox virus. The Monkeypox Information Center is hosted on Elsevier Connect, the company's public news and information website.

Short Communication

Public sentiment on the global outbreak of monkeypox: an unsupervised machine learning analysis of 352,182 twitter posts

Q.X. Ng [a], C.E. Yau [b], Y.L. Lim [b], L.K.T. Wong [c], T.M. Liew [d, e, f, *]

[a] Health Services Research Unit, Singapore General Hospital, Singapore 168582, Singapore
[b] NUS Yong Loo Lin School of Medicine, National University of Singapore, Singapore 117597, Singapore
[c] School of Medicine, Trinity College Dublin, The University of Dublin, Dublin D02 PN40, Ireland
[d] Department of Psychiatry, Singapore General Hospital, Singapore 169608, Singapore
[e] SingHealth Duke-NUS Medicine Academic Clinical Programme, Duke-NUS Medical School, Singapore 169857, Singapore
[f] Saw Swee Hock School of Public Health, National University of Singapore, Singapore 117549, Singapore

ARTICLE INFO

ABSTRACT

Objectives: This study aimed to study the public's sentiments on the current monkeypox outbreaks via an unsupervised machine learning analysis of social media posts.
Study design: This was an exploratory analysis of tweets sentiments.
Methods: We extracted original tweets containing the terms 'monkeypox', 'monkey pox' or 'monkey_pox' and posted them in the English language from 6 May 2022 (first case detected in the United Kingdom) to 23 July 2022 (when World Health Organization declared Monkeypox to be a global health emergency). Retweets and duplicate tweets were excluded from study. Bidirectional Encoder Representations from Transformers (BERT) Named Entity Recognition. This was followed by topic modelling (specifically BERTopic) and manual thematic analysis by the study team, with independent reviews of the topic labels and themes.
Results: Based on topic modelling and thematic analysis of a total of 352,182 Twitter posts, we derived five topics clustered into three major themes related to the public discourse on the ongoing outbreaks. These include concerns of safety, stigmatisation of minority communities, and a general lack of faith in public institutions. The public sentiments underscore growing (and existing) partisanship, personal health worries in relation to the evolving situation, as well as concerns of the media's portrayal of lesbian, gay, bisexual, transgender and queer and minority communities, which might further stigmatise these groups.
Conclusions: Monkeypox is an emerging infectious disease of public concern. Our study has highlighted important societal issues, including misinformation, political mistrust and anti-gay stigma that should be sensitively considered when designing public health policies to contain the ongoing outbreaks.

Introduction

Monkeypox is endemic to West and Central Africa, and before the current outbreaks, almost all cases outside of Africa were linked to international travel or through imported animals (zoonosis).[1] In contrast, the current outbreak seems largely confined to homosexual and bisexual men, and the virus may have become more infectious or be capable of other modes or asymptomatic transmission, which had allowed it to spread around the world rapidly.[2] This has fuelled concerns that this outbreak could evolve into a global pandemic.

As there are still several questions and uncertainty at this stage, there are bound to be concerns and anxiety among the general public towards the emerging situation. An important aspect of public health policy is designing and managing public communications. To do so, previous studies have found that social media analyses via Twitter are a feasible and novel method to study public sentiment and emotional manifestations on a given topic.[3,4] Therefore, in this infodemiology study, we aimed to study the public sentiments on the emerging global outbreak of monkeypox and, in doing so, highlight and hopefully address the public's concerns.

* Corresponding author. Department of Psychiatry, Singapore General Hospital, 169608, Singapore. Tel.: +65 6222 3322.
E-mail addresses: liew.tau.ming@singhealth.com.sg, ephltm@nus.edu.sg (T.M. Liew).

Methods

Original tweets containing the terms 'monkeypox', 'monkey pox' or 'monkey_pox' and posted in English language from 6 May 2022 (first case detected in the United Kingdom) to 23 July 2022 were extracted. Retweets and duplicate tweets were excluded from study. Bidirectional Encoder Representations from Transformers (BERT) Named Entity Recognition[5] was then applied to select individual users only. Topic modelling, specifically BERTopic,[6] was used to generate coherent key concerns on the public discourse surrounding monkeypox. R (version 3.6.3) and Python (version 3.7.13) were used for all quantitative analyses.

Thematic analysis was then performed iteratively and inductively with independent reviews of the topic labels and themes. Coding disagreements were resolved through discussion amongst the study authors until a consensus was reached.

This study did not directly involve human participants.

Results

A total of 1,028,326 initial tweets were identified in the period of 6 May to 23 July 2022. A flowchart illustrating the tweets selection process with the help of unsupervised machine learning technology was shown in Fig. 1.

BERTopic generated five topics related to the public discourse surrounding monkeypox, and the total prevalence of these five topics was 68.9%; the remaining 31.1% was from a topic that was omitted from the current results as the model generates a Miscellaneous topic that groups all remaining (unfitted) tweets together. Thematic analysis grouped the five topics into three major themes. Table 1 contained the details of the topics and sample tweets within each theme.

Discussion

In this infodemiology study, we used unsupervised machine learning to analyse a large volume of free-text data from social media tweets and further categorised the arising broad themes through iterative thematic analysis. The public sentiments surrounding the global outbreak of monkeypox can be broadly demarcated into three themes: (1) concerns of safety, (2) stigmatisation of minority communities, and (3) lack of faith in public institutions.

First, the concerns of safety are expected, especially while the world is still embattled by the COVID-19 pandemic. The steep rise in the number of monkeypox cases bears at least some resemblance to the early stages of the also likely zoonotic originating severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.
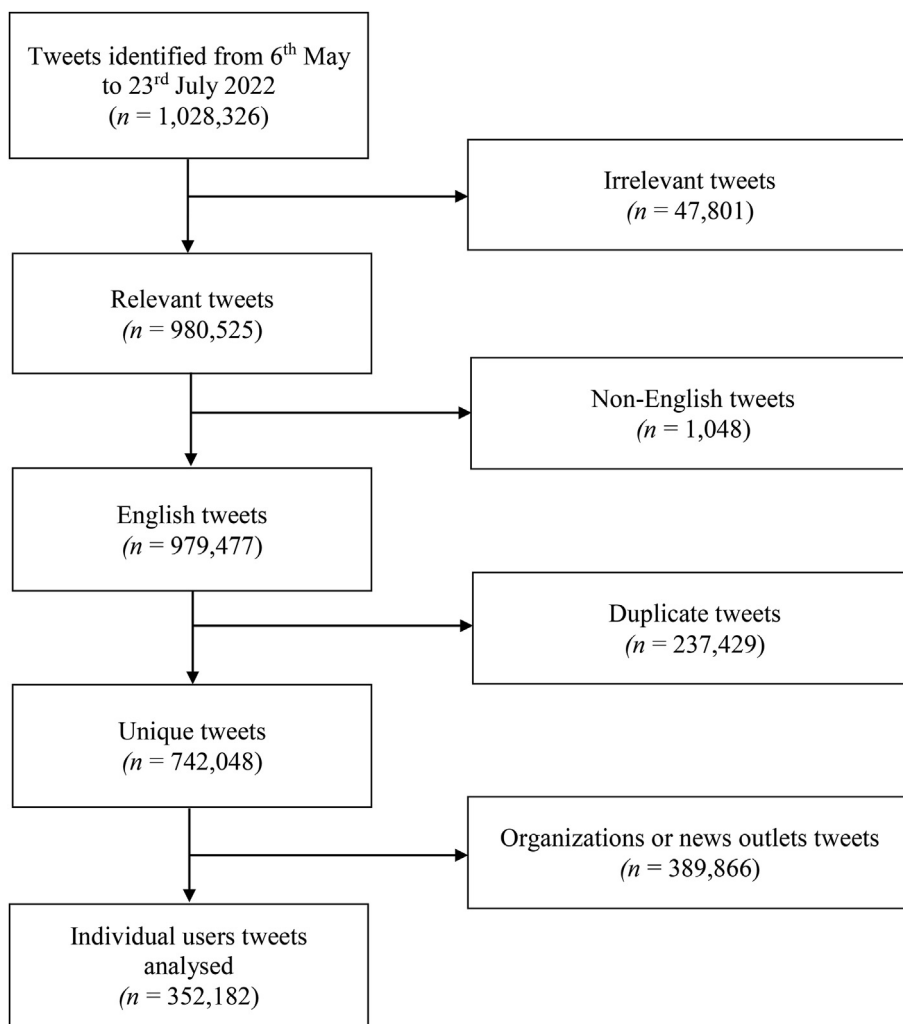

Fig. 1. Flowchart illustrating tweets selection process.

Table 1
Three themes related to the global Monkeypox situation, along with the respective topics and sample tweets (N = 352,182).

Theme and topic (keywords)	Sample tweets	Number of tweets, n (%)
Theme 1: Concerns about personal safety		
Topic 1: Concerns about the escalating spread of Monkeypox outbreak (*smallpox vaccine, reported, immune, county, doses, pox monkeypox, vaccine monkeypox, monkey pox monkeypox, endemic, international*)	"Monkey pox outbreak after debauchery month? Who would have thought?" "Monkey pox. Monkey pox is happening" "So now monkey pox about to be on y all ass"	188,102 (53.4)
Topic 3: Misconception on protective ability of face masks (*wearing mask, wearing masks, wear masks, mask monkeypox, n95, air, recommends, mask monkey pox, monkeypox masks, monkeypox mask*)	"And where on our body exactly are we supposed to wear them to prevent monkeypox ?" "I started using latex gloves again, along with a mask. I don t want Covid or MonkeyPox. Watched a video yesterday that recommended the gloves - especially at the gas station and grocery store." "I wear masks whenever I'm indoors with other people. It's just sensible, Covid has not ceased to exist, and monkeypox is spread through droplets, too. I have also avoided my usual winter colds and flu."	7212 (2.1)
Theme 2: Stigma towards minority communities		
Topic 2: Stigma towards lesbian, gay, bisexual, transgender and queer (LGBTQ) and racial minority communities (*community, transmission, pride, bisexual, sexually, gays, lgbtq, close contact, gay bisexual, monkeypox gay*)	"I see the WHO is declaring war on the gays. They are being fingered to bare [sic] the brunt for the monkeypox. Let s [sic] see this will end up." "I was not fearful of Covid, I'm not fearful of monkeypox but being gay I'm fearful of people who believe this being a gay disease." "These articles doing reporting on Monkey Pox keep showing images of Black people when there is no correlation. They know exactly what they're doing. NBC did the same thing."	39,947 (11.3)
Theme 3: Lack of faith in institutions		
Topic 5: Lack of faith in governmental efforts to contain Monkeypox (*biden monkeypox, biden administration, biden says, monkeypox biden, admin, president biden, biden admin, biden said, pox biden, monkey pox biden*)	"A full 56% of #American #voters say they don't #trust that the #Biden #Administration and the #President's chief #medical #adviser Dr. #AnthonyFauci will handle the #Monkeypox #outbreak properly, #GOP #Midterms2022." "President Biden said that the new monkeypox outbreak should concern everybody My concern is how this shit came to the US in a first place? Southern border? So, should we be focusing on fixing this problem first?'" "I m blaming Biden for the Monkey Pox outbreak probably brought over from illegals that aren t vetted or even checked out to make sure they aren t contagious."	2828 (0.8)
Topic 4: Misinformation on Monkeypox as a political conspiracy (*ballots, mail ballots, democrat, midterm elections, mid terms, terms, time midterms, cheat, nov, variant*)	"Dems have run through every conceivable 'controversy' [sic] to try and destroy America. Covid Lockdowns Mandates Jan 6 Afghanistan Inflation Food shortage Gas prices Crime On and on. They tried Monkey Pox. THEYLL DO ANYTHING TO STAY IN POWER ANYTHING." "Monkeypox?!!!! What will the Dems think of next? Have to have another virus to screw up midterms. America, have you had enough of this insanity?" "Monkey Pox … suddenly being elevated right on schedule with the 2022 Mid-terms …. and given the past two years of Authoritarian like control, one can already predict how this is going to go …"	4629 (1.3)

Collectively, Topics 1 and 3 reflect the public's fear that with the escalating spread of monkeypox, coupled with the World Health Organization recently declaring monkeypox to be a global health emergency of international concern, that monkeypox might morph into the next pandemic. The public's worry surrounding monkeypox also mirrors that of COVID-19 in the early months of 2020, with anger and fear being the predominant negative emotion.[7] While monkeypox is not as transmissible as COVID-19, and there is an available vaccine (i.e. the smallpox vaccine) that offers good protection against monkeypox, the threat of cross-border transmission is still present and real, especially with increasing global travel and interconnectedness. Robust public health surveillance and communication are very much required, both to curb the spread of monkeypox, public anxiety and misinformation.

Specifically, accurate and timely dissemination of information related to monkeypox (how it is transmitted, how to avoid contracting monkeypox, etc.) is crucial, and public health officials should note the rising public conversation (as evident by Topic 3) on whether face mask can help to prevent monkeypox. This is a particularly interesting conversation picked up with such social media analysis; and public health communications can specifically target at correcting this misunderstanding (as well as provide the correct scientific way to protect oneself).

On a related note, it is vital to address the eroded faith that people have in governmental and public health organisations. It is important to acknowledge that this lack of faith has reared its ugly head even during the COVID-19 pandemic. As reflected in Topics 4 and 5, this lack of faith probably stems from both a perceived inadequacy of governmental institutions and, at its extremes, being highly partisan and viewing public health information as "fake news" or as a conspiracy. This and other precedents forebode a gloomy future for public health messaging, not just in the United States but in countries with low trust in their institutions. Existing literature already indicates that increased public trust in

government is significantly associated with positive preventive health behaviour and prosocial behaviour.[8] The converse is true, and this might impede the government's efforts to control the growing outbreak and result in further partisanship in areas beyond politics. Monkeypox is not the first time partisanship has adversely influenced people's attitudes towards a condition of public health significance nor will it be the last. Burgeoning research has shown the pernicious effects of echo chambers and how disinformation seeds more disinformation.[9] It has been shown that in the case of COVID-19, 'anti-science' attitudes became more deeply embedded within a network of sceptical beliefs as the pandemic progressed. Thus, for the ongoing monkeypox outbreak, it is of utmost importance that public health organisations have unequivocal messaging and continue to strengthen international partnerships to foster confidence and actively counter pre-existing political distrust of public health information. Given that partisanship already exists and may affect one's beliefs in the veracity of the information presented, public health organisations should also actively reach out and engage the different political parties for concerted efforts in public health communication.

Finally, the high proportion of monkeypox patients who identify as LGBTQ+ and media content featuring predominantly Black individuals have resulted in stigmatising media portrayals of marginalised communities.[10] This has serious implications on several levels. With the disproportionate focus on men who have sex with men communities, the public may neglect the fact that monkeypox can also be spread through non-sexual means, such as skin-to-skin contact or touching items and surfaces that have been contaminated by skin lesions. Furthermore, stigma may dissuade and discourage patients' health seeking behaviour, engagement in care and adherence to treatment. Gay communities may already suffer discrimination and microaggressions and be reluctant to come forward to seek medical care. There is an effective vaccine for postexposure prophylaxis, and prompt case reporting and isolation for symptomatic cases are essential to reduce the likelihood of further transmission. It is therefore vital that public messaging be mindful of these nuances and authorities should actively counter misinformation, stigmatising portrayals and rebuild the public's faith in institutions. Primary care practitioners should also be equipped with the tools and knowledge to provide culturally sensitive interventions for LGBTQ+ populations so that individuals would feel comfortable to seek medical attention, especially as the skin lesions for individuals with monkeypox may occur in the genital or perianal areas. Public health institutions could also engage respectable key opinion leaders in the LGBTQ+ community to provide the correct public messaging on monkeypox transmission, signs and symptoms, available help and prophylaxis.

Nonetheless, the limitations of the present study include the rapidly evolving nature of the monkeypox outbreak and the fact that the analysis was based on Twitter posts (with the majority of users from North America and Europe), and only tweets in English were eligible for inclusion. Hence, the findings may change over time depending on the outbreak trajectory and may not necessarily generalise to all populations and communities.

Conclusion

In conclusion, the present study highlights the key public sentiments and societal issues underlying the global monkeypox outbreak. Perhaps owing to the variation in the epidemiology of cases and case transmission of the ongoing outbreak, it has brought to the surface existing societal issues, including misinformation, political mistrust and LGBTQ+ stigma that should be taken into account sensitively in the design of public health communications and policies to contain the outbreaks.

Author statements

Author contributions

T.M.L. conceived the original idea. Q.X.N., C.E.Y., Y.L.L., L.K.T.W. and T.M.L. carried out the study and the relevant data analysis and interpretation. All authors contributed to the data analysis and interpretation. All authors discussed the results, contributed to the writing of the paper and approved the final article.

References

1. Yinka-Ogunleye A, Aruna O, Dalhat M, Ogoina D, McCollum A, Disu Y, et al. Outbreak of human monkeypox in Nigeria in 2017-18: a clinical and epidemiological report. *Lancet Infect Dis* 2019;**19**(8):872—9.
2. León-Figueroa DA, Bonilla-Aldana DK, Pachar M, Romaní L, Saldaña-Cumpa HM, Anchay-Zuloeta C, et al. The never-ending global emergence of viral zoonoses after COVID-19? The rising concern of monkeypox in Europe, North America and beyond. *Trav Med Infect Dis* 2022;**49**:102362. May 26.
3. Tsai MH, Wang Y. Analyzing twitter data to evaluate people's attitudes towards public health policies and events in the era of COVID-19. *Int J Environ Res Publ Health* 2021;**18**(12).
4. Liew TM, Lee CS. Examining the utility of social media in COVID-19 vaccination: unsupervised learning of 672,133 twitter posts. *JMIR Public Health Surveill* 2021;**7**(11):e29789. Nov 3.
5. Devlin J, Chang M-W, Lee K, Toutanova K. *BERT: pre-training of deep bidirectional Transformers for language understanding*. arXiv. 2019. 2019/05/24/. Report No.: arXiv:1810.04805.
6. Grootendorst M. *BERTopic: neural topic modeling with a class-based TF-IDF procedure*. arXiv;. 2022. 2022/03/11/. Report No.: arXiv:2203.05794.
7. Lwin MO, Lu J, Sheldenkar A, Schulz PJ, Shin W, Gupta R, et al. Global sentiments surrounding the COVID-19 pandemic on twitter: analysis of twitter trends. *JMIR Public Health Surveill* 2020;**6**(2):e19447.
8. Han Q, Zheng B, Cristea M, Agostini M, Bélanger JJ, Gützkow B, et al. Trust in government regarding COVID-19 and its associations with preventive health behaviour and prosocial behaviour during the pandemic: a cross-sectional and longitudinal study. *Psychol Med* 2021:1—11.
9. Priniski JH, Holyoak KJ. A darkening spring: how preexisting distrust shaped COVID-19 skepticism. *PLoS One* 2022;**17**(1):e0263191.
10. UNAIDS. UNAIDS Warns that stigmatizing language on Monkeypox jeopardises public health. [Accessed 26 Jul 2022] Available from: https://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2022/may/20220522_PR_Monkeypox.