Short communication

How loneliness is talked about in social media during COVID-19 pandemic: Text mining of 4,492 Twitter feeds

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ABSTRACT

Background: Loneliness is a public health problem that is expected to rise during the COVID-19 pandemic, given the widespread policy of quarantine. The literature is unclear whether loneliness during COVID-19 is similar to those of non-pandemic seasons. This study examined the expression of loneliness on Twitter during COVID-19 pandemic, and identified key areas of loneliness across diverse communities.
Methods: Twitter was searched for feeds that were:(1) in English; (2) posted from May 1, 2020 to July 1, 2020; (3) posted by individual users (not organisations); and (4) contained the words 'loneliness' and 'COVID-19'. A machine-learning approach (Topic Modeling) identified key topics from the Twitter feeds; Hierarchical Modeling identified overarching themes. Variations in the prevalence of the themes were examined over time and across the number of followers of the Twitter users.
Results: 4492 Twitter feeds were included and classified into 3 themes: (1) Community impact of loneliness during COVID-19; (2) Social distancing during COVID-19 and its effects on loneliness; and (3) Mental health effects of loneliness during COVID-19. The 3 themes demonstrated temporal variations. Particularly in Europe, Theme 1 showed a drastic reduction over time, with a corresponding rise in Theme 3. The themes also varied across number of followers. Highly influential users were more likely to talk about Theme 3 and less about Theme 2.
Conclusions: The findings reflect close-to-real-time public sentiments on loneliness during the COVID-19 pandemic and demonstrated the potential usefulness of social media to keep tabs on evolving mental health issues. It also provides inspiration for potential interventions to address novel problems–such as loneliness–during COVID-19 pandemic.

1. Introduction

Loneliness refers to a complex emotion of anxiety and dissatisfaction related to a lack of connectedness or communality with others. It often arises from a discrepancy between the actual and the desired amount of social engagement (Victor et al., 2005), resulting in a subjective feeling of isolation. Loneliness has been reported to affect around 30% of older people as reported in studies conducted in various countries (Ong et al., 2016). Although it is widely stereotyped to increase with age, the association between loneliness and age is only true in extreme old age (i.e. after 80 years old) (Pinquart and Sorensen, 2001). Other risk factors of loneliness include a low socioeconomic status (Pinquart and Sorensen,

2001), living in an institution (Pinquart and Sorensen, 2001), having a low activity level (Pinquart and Sorensen, 2001), and social isolation (Tanskanen and Anttila, 2016). In the literature, loneliness has been associated with numerous health complications, including mental health conditions such as depression (Erzen and Çikrikci, 2018), cognitive impairment (Boss et al., 2015), and suicidal ideation (Chang et al., 2017); and physical health conditions such as coronary heart disease (Valtorta et al., 2016), stroke (Valtorta et al., 2016), and overall mortality (Blazer, 1982; Hackett et al., 2012; Heidari Gorji et al., 2019; Holt-Lunstad et al., 2010). Notably, the overall mortality risk associated with loneliness was comparable to those of established cardiovascular risk factors such as obesity and smoking (Holt-Lunstad et al., 2015).
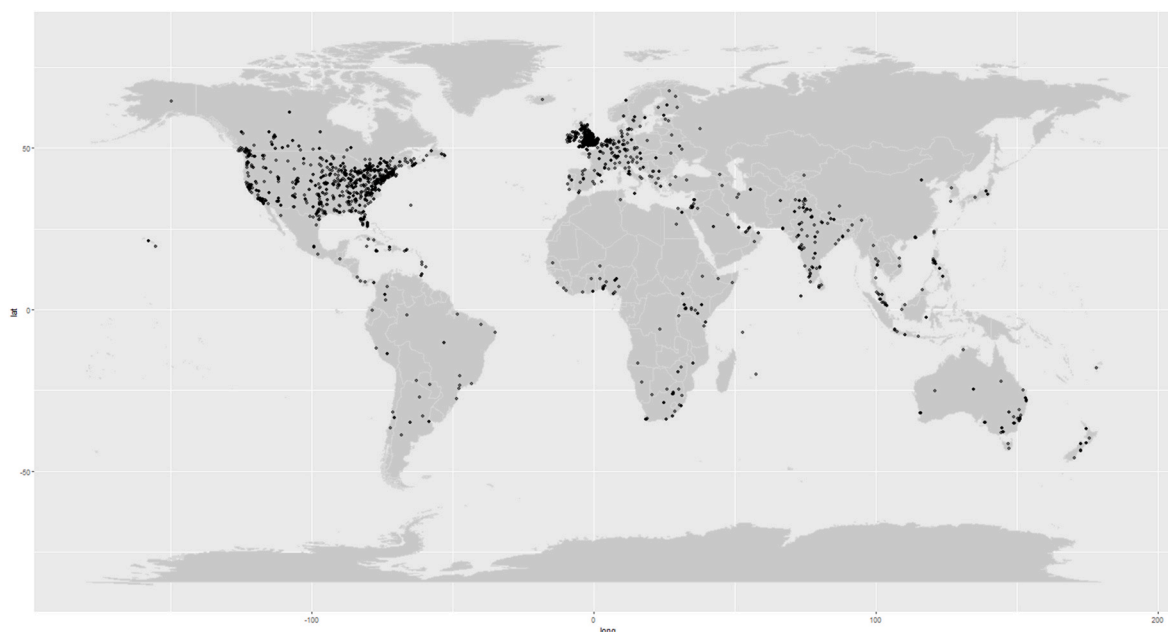
Fig. 1. Geographical distribution of the Twitter feeds.

Given the ongoing Coronavirus Disease–2019 (COVID-19) pandemic, the problem of loneliness is only expected to rise further as governments around the world enforce stay-at-home directives and social distancing measures to curb the spread of the virus. Recent literature is already seeing a rising trend in loneliness among the quarantined population in Wuhan, China (Banerjee and Rai, 2020). Alongside this, there has also been an increase in the prevalence of other related mental health outcomes in this COVID-19 period, including depression, stress and anxiety (Torales et al., 2020), which may further compound the impact of loneliness. However, to date, the literature is unclear whether the experience of loneliness during COVID-19 shares similar characteristics to those that were experienced during non-pandemic seasons; and whether similar coping strategies were also employed to manage the profound loneliness during this pandemic. Without such clarity in our understanding on COVID-19-related loneliness, it can be challenging for policymakers to decide on whether there is a need to modify existing social policies, and whether there is a need for a different approach to address issues that are unique to this pandemic season.

Traditionally, research in the area of loneliness often rely on methodologies such as surveys, interviews, structured questionnaires (Hawkley and Cacioppo, 2010) or focus group discussions (Cohen-Mansfield et al., 2016). However, given the current pandemic and the need for social distancing, these typically in-person approaches may become more challenging to conduct. An alternative would be using data from social media platforms such as Twitter, where members of the public can still express their thoughts and connect with others while complying with social distancing directives. In addition, the use of social media posts can also have other added advantages compared to traditional methods, whereby researchers can collect near real-time sentiments that reflect the perspectives and feelings of the community. In this study, we sought to examine how loneliness and its related topics were being discussed on Twitter during the COVID-19 pandemic, and potentially shed some light on the key areas of loneliness (such as its impact and the frequently used coping strategies) across diverse communities.

2. Methods

Twitter was selected as the social media platform of choice, due to the public availability of Twitter feeds and the relative ease of collecting

massive amounts of data in Twitter. It is also of note that Twitter is the third most popular social media platform in the United Kingdom (YouGov, 2019) and is used by one-quarter of people in the United States (Murnane, March 3, 2018). All data used in this study were collected according to the Twitter terms of use and were publicly available at the time of collection and analysis. The protocol for this study was reviewed by the Singhealth Centralized Institutional Review Board and was determined to meet the criteria for exempt human subjects' research.

We searched Twitter feeds that were posted in English from May 1, 2020 to July 1, 2020, using the search terms 'loneliness' (or 'lonely') and 'COVID-19' (or similar terms such as 'COVID', 'COVID19', 'coronavirus', and 'corona virus'). To be included in this study, each Twitter feed should include the words 'loneliness' (or 'lonely') and 'COVID-19' (or 'COVID', 'COVID19', 'coronavirus', and 'corona virus') within its freetext. To focus on individual's sentiments of loneliness (and minimize the selection of objective reports of loneliness such as those in news articles), only Twitter feeds that were posted by individual users (and not organisations or news outlets) were included in this study. Individual Twitter users were identified by the use of actual human names on the Twitter account of each post – this process (identifying human names) was conducted using a machine-learning approach of Natural Language Processing.

As the Twitter feeds involve large volumes of free-text data, a machine-learning approach was used to analyse these data, using a textmining technique also known as Topic Modeling (Banks et al., 2018). Topic Modeling is an unsupervised machine-learning technique that identifies key topics within free-text data, based on statistical probability and correlations among words. It is akin to the thematic analysis in traditional qualitative methodology. But unlike thematic analysis, Topic Modeling does not require manual labor to classify the free-text data and hence is well-suited for analyses of large volumes of free-text data (Banks et al., 2018) such as in this study.

Prior to conducting Topic Modeling, the following steps were done to pre-process the free-text data based on currently recommended bestpractices (Banks et al., 2018). First, each sentence in the Twitter feeds was reduced to individual words. For example, a sentence 'John celebrated his birthday with his best friends' is reduce to individual words of 'John', 'celebrated', 'his', 'birthday', 'with', 'his', 'best' and 'friends'. Then, stop words were removed from the lists of words. Stop words refer to words that occur so frequently in the English language that they do
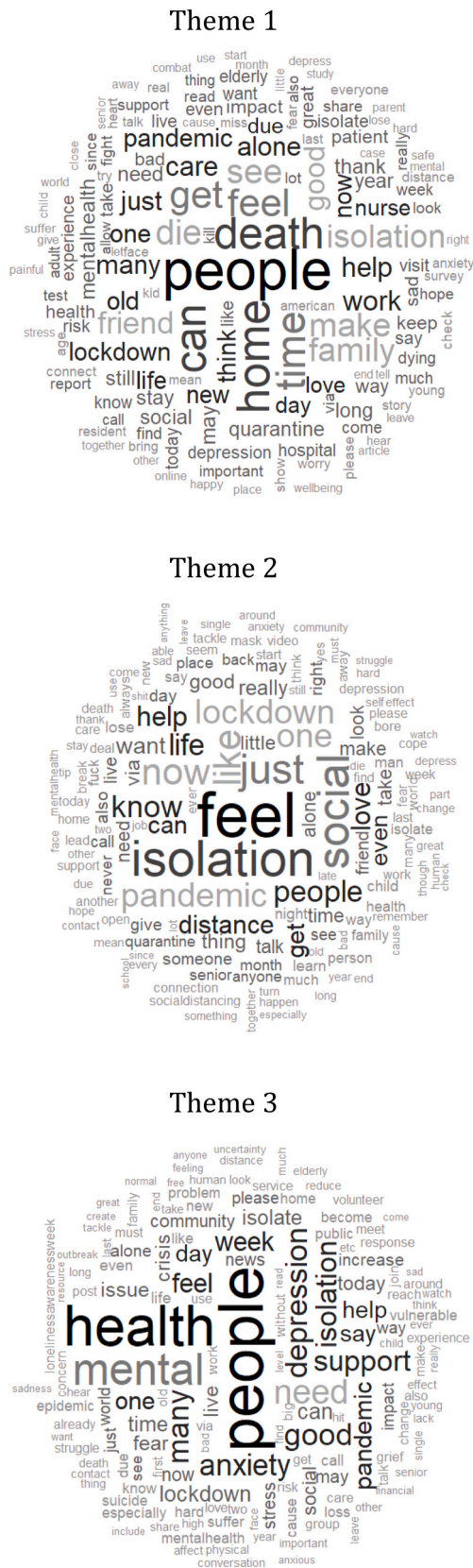
Theme 1

Theme 2

Theme 3

Fig. 2. Word cloud for the three key themes related to loneliness and COVID-19.

not add value in the identification of topics (for example, words such as 'and', 'the', 'a' and 'of'). Next, the remaining words were converted to their 'root' form. Using the sample sentence above by way of example, 'celebrated' would be converted to 'celebrate', 'best' to 'good', and 'friends' to 'friend'. Lastly, words that occurred in less than 50 Twitter feeds were removed to reduce statistical noise and improve accuracy (Banks et al., 2018).

In Topic Modeling, the processed words were presented to the unsupervised machine-learning algorithm to identify clusters of words that tended to co-occur. Words that have high probability of co-occurring in Twitter feeds were then considered to belong to the same 'topic'. Three covariates were included in the Topic Modeling (continent of Twitter feeds, date of Twitter feeds, and number of followers of the Twitter user) to improve the accuracy of the model in identifying the topics. The optimal number of topics were identified using the algorithm proposed by Lee and Mimno (2014) (Mimno and Lee, 2014). After identifying the optimal number of topics, those topics that were related to each others could be further lumped together to form a theme – this clustering approach was conducted using Hierarchical Clustering method, with the optimal number of themes identified through the elbow method (James et al., 2013). After identifying the optimal number of topics and themes from the Twitter feeds, the descriptive label for each topic/theme was manually crafted by the authors based on the keywords and sample Twitter feeds within each topic/theme.

All analyses were performed in R (version 3.6.3), using the 'rtweet' package (Kearney, 2019) to extract Twitter feeds, the 'spacyr' package (Kenneth Benoit) to identify individual users in Twitter accounts, the 'quanteda' package (Benoit et al., 2018) to pre-process the free-text data, the 'stm' package (Roberts et al., 2019) to conduct the Topic Modeling, and the 'ClustOfVar' package (Chavent et al., 2012) to conduct the Hierarchical Clustering.

3. Results

A total of 19,095 Twitter feeds were initially identified in the period of May 1, 2020 to July 1, 2020. After removing Twitter feeds without relevant terms of "loneliness" and "COVID-19", removing duplicate posts as well as removing Twitter feeds by organisations, a final 4492 Twitter feeds were included in the study. Flow diagram related to the selection of Twitter feeds is further presented in **Supplementary Material 1**, while the geographical distribution of the Twitter feeds is shown in Fig. 1. Most of the posts originated from North America (32.9%) and Europe (24.5%), while the rest were from Asia (5.2%), Africa (3.9%), Australia (2.3%), South America (0.9%) or unknown location (30.4%).

Altogether, 33 topics were identified from the included Twitter feeds, and their relationships among each other can be further visible in the dendrogram from Hierarchical Clustering (Supplementary Material 2). The 33 topics could possibly be clustered into 3 key themes using Hierarchical Clustering, as suggested by the elbow method (Supplementary Material 3) (the sharp bent between the third and fourth cluster suggested limited gain of including four clusters instead of three clusters). Word cloud of the 3 themes is shown in Fig. 2, while the respective topics and sample texts within each theme are presented in Table 1. Theme 1 was talked about in 41.3% of the Twitter feeds, and involves keywords such as death, home, work and hope. It describes the **Community impact of loneliness during COVID-19**, and includes topics such as Hope during COVID-19 (4.3%), News articles on impact of loneliness and ways of addressing them (4.2%) and Loneliness affects all groups of people (4.0%). Theme 2 was talked about in 30.9% of the Twitter feeds, and involves keywords such as isolation, distance, feel and lockdown. It describes **Social distancing during COVID-19 and its effects on loneliness**, and includes topics such as Differences between social distancing and social isolation (4.7%), Contrast of relationships before and after quarantine measures (4.3%) and Cravings for intimacy and comfort to cope with loneliness in social isolation (3.8%). Theme 3

Table 1
The respective topics within each themes, related to loneliness and COVID-19.

Theme	Topic (keywords)	Sample Twitter feeds	Prevalence (%)
Theme 1: **Community impact** of loneliness during COVID-19	Topic 31: Hope during COVID-19 *(can, see, thank, lot, hope)*	"eid_mubarak!this eid separately but, we can get much of love and care beyond the cold walls of loneliness. this eid is about caring and the passion to share the joy and laughter as much as we can. wish you all a happy eid eid covid19 stayathome staysave"	4.3
	Topic 1: News articles on impact of loneliness and ways of addressing them *(time, new, great, experience, long)*	"a new article in time about covid and loneliness, in which i mention the importance of shield."	4.2
	Topic 27: Loneliness affects all groups of people *(get, think, sad, keep, try)*	"so lit. everyone's getting real lonely during the covid season lol"	4.0
	Topic 18: Loneliness and fear of COVID-19 in nursing homes *(home, care, nurse, patient, elderly)*	"heartbreak in nursing homes, dying from loneliness amid covid-19 visiting restrictions"	3.9
	Topic 9: Loneliness affected by work and social media *(make, work, stay, connect, feel)*	"tech and social media are making us feel lonelier than ever the loneliness paradox: all that time online can connect us in amazing ways, but it can also make us feel isolated. Coronavirus"	3.5
	Topic 19: Fear of a painful and lonely death from COVID *(death, die, let, suffer, painful)*	" well, duh. of course the do and it's not most likely, it is covid19 pneumonia deaths. a horrific, painful, lonely death."	3.2
	Topic 2: Older adults are more likely to be affected by the effects of loneliness *(old, year, report, age, adult)*	"'older adults holding an older age identity are more susceptible to the adverse effects of loneliness' covid-19-related loneliness and psychiatric symptoms among older adults: the buffering role of subjective age"	3.0
	Topic 24: Ways of coping with loneliness during COVID-19 *(quarantine, risk, come, fight, test)*	"to stem feelings of loneliness exacerbated by the covid-19 quarantine, apps and software programs are springing up to offer companionship and advice."	2.9
	Topic 12: Effect of COVID-19 on caregivers of patients with mental illness *(mentalhealth, impact, worry, survey, wellbeing)*	"we are keen to understand the impact of covid19 on the mentalhealth wellbeing loneliness of carers supporting people with poor mentalhealth around the world …. ."	2.7
	Topic 10: Anger and displeasure against the US government for opening the nation *(still, read, face, kill, american)*	"usa covid19 the administration is effectively bowing to - and asking americans to accept - a devastating proposition: that a steady, daily accumulation of lonely deaths is the grim cost of reopening the nation"	2.6
	Topic 8: Connecting with friends and family through phones *(family, friend, check, miss, phone)*	"covid has illuminated the reasons why having access to broadband is so essential, especially for olderadults. Rich offerings, contact with family and friends. essential for helping to mitigate the socialisolation and loneliness this virus attacks"	2.6
	Topic 26: People's increasing desire to travel out of one's home and city *(due, visit, since, bad, kid)*	"i can't wait to leave the state of nc this weekend shit been mad lonely since covid"	2.5
	Topic 28: Coping with loneliness through creative arts *(alone, show, mean, tell, disease)*	"a song for our covid19 world? i'll show you ruin i'll show you heartbreak i'll show you lonely, a sorrow in darkness …. "	2.0
Theme 2: **Social distancing** during COVID-19 and its effects on loneliness	Topic 13: Difference between social distancing and social isolation *(isolation, social, distance, learn, lead)*	"we must be cautious that social distancing does not lead to social isolation …. Isolation and loneliness are a risk factor for a variety of psychological conditions …. Covid19 india"	4.7
	Topic 3: Contrast of relationships before and after quarantine measures *(lockdown, pandemic, love, talk, another)*	"you don't realize how much a handshake or a hug means until you can't do it anymore covid19 pandemic lockdown lonely"	4.3
	Topic 29: Craving for intimacy and comfort to cope with loneliness in social isolation *(just, know, want, really, someone)*	"… all shops are closed at this hour coz fuck you u fucking fuck covid19. I'm just a shitfaced lonely man who wants his broke ass comfort food."	3.8
	Topic 6: Expressing the feelings of loneliness during quarantine *(feel, like, person, every, bore)*	"how does it feel to be lonely? loneliness is worthlessness. you feel you don't fit in, that people don't understand you. you feel terrible about yourself, you feel rejected. i'm hopeful that covid19 heightens our urgency to treat loneliness."	3.7
	Topic 17: Coping with isolation using various methods (music/shopping/prayer) *(life, one, thing, love, give)*	"i find this to be a great message. Given the added stress of covid some may be inclined to make rash purchases of things that profess to make life nice and tranquil or for some less lonely"	3.1
	Topic 14: Contrast of emptiness in previously crowded places *(now, little, place, look, lose)*	"britain is in a lonely place right now. It resembles the scene of a bad traffic accident where shocked passers-by look away with pity and horror in their eyes … once again, britain is the sick man of europe. coronavirus"	3.1
	Topic 30: Desire to be able to meet with family and friends *(take, also, month, back, away)*	"i'm sorry that you're feeling lonely. has the coronavirus quarantine been keeping you away from family and friends? hopefully you'll meet up with friends and/or family again soon …. "	2.4
	Topic 11: Available community services to help reduce loneliness during isolation *(help, via, call, can, good)*	"a new befriending service will match a covid-19 volunteer friend with those over 60 who are feeling lonely & enable them to connect with each other via phone calls. Request this service …"	2.1
	Topic 22: Interacting with others help reduce loneliness for children and elderly *(child, senior, other, tackle, cope)*	"gridforgood senior chatline connecting seniors who are experiencing loneliness and isolation from covid-19 restrictions. Joint partnership with engaging seniors for social hour of the day, lifting their hearts …"	2.0
	Topic 25: Frustration stemming from loneliness *(even, right, start, never, now)*	"god, i hate feeling restless and lonely. I could do with some cuddles right now, but i can't fucking do anything because of the corona virus that's	1.7

Table 1 (*continued*)

Theme	Topic *(keywords)*	Sample Twitter feeds	Prevalence (%)
		been going around and it's starting to get to me to the point where i'm starting to feel depressed almost all the time …"	
Theme 3: **Mental health effect** of loneliness during COVID-19	Topic 21: Difficulty coping with loneliness during COVID-19 *(people, live, today, community, without)*	"young people who live with or visit elders or people in vulnerable groups have to be extra careful. But many don't. Most are now unemployed, living sad and lonely lives in bedsits. also there's no evidence people catch covid outside."	4.2
	Topic 7: Social interaction as a basic human need *(need, support, isolate, please, especially)*	"… of all ways we communicate, the roots of non-verbal communication run the deepest. covid-19 has deprived us of the closeness we are biologically programmed to need when we are vulnerable, lonely or fearful - exactly when we need it most …"	4.1
	Topic 15: Loneliness increases mental health problems *(health, mental, crisis, issue, increase)*	"poignant reminder from with discussing the looming "2nd health crisis" within the covid19 pandemic - rising rates of mental health concerns brought about from the isolation, loneliness and anxiety …"	3.8
	Topic 32: Psychological distress from COVID-19 *(depression, anxiety, fear, stress, loss)*	"my heart hurts for those struggling/suffering/hurting/dying from psychological impacts of covid19 like anxiety addiction depression fear grief loneliness ptsd suicide trauma violence. pain is real. I'm here for you. no judgement. let's heal together. Thesuicidenetwork"	3.2
	Topic 4: Descriptions of loneliness as an emotional struggle *(day, one, say, hard, already)*	"… every day the covid19 crisis continues, socialisolation and loneliness become harder and harder to battle."	3.0
	Topic 23: Community efforts to address the impact of loneliness during COVID-19 *(week, last, two, meet, loneliness awareness week)*	"if you are feeling lonely, have a look for groups near you who are offering support during the coronavirus pandemic …. "	2.8
	Topic 5: Recognizing loneliness as a problem *(good, use, human, big, concern)*	"in all the undoubted complexity of how to best restrict the spread of covid-19, we must not forget that the first thing that god saw as 'not good' in creation was human loneliness. (gen 2:18)"	1.8
	Topic 16: News articles on emotional struggles associated with loneliness *(many, news, end, struggle, watch)*	"Coronavirus: 'too many people are lonely and struggling', says pm | politics news …"	1.8
	Topic 33: Using writing to cope with the mental health impact of loneliness during COVID-19 *(may, write, way, say, people)*	"connectivity keeps us going. writing is magic. Australia is using letter-writing to combat senior loneliness in this age of covid …."	1.6
	Topic 20: Reflections on daily lives during COVID-19 *(world, must, around, post, leave)*	"my life pre-covid collapsed into a single memory: standing in a lonely hotel room ironing a dress shirt. My life post-covid collapsed into a single memory: standing by the toaster spreading cream cheese on bagels."	1.6

was talked about in 27.8% of the Twitter feeds and involves keywords such as health, anxiety, depression and support. It describes **Mental health effect of loneliness during COVID-19** and includes topics such as Difficulty coping with loneliness during COVID-19 (4.2%), Social interaction as a basic human need (4.1%) and Loneliness increases mental health problems (3.8%).

Fig. 3 presents the variations in the prevalence of the themes over time. The 3 themes had largely constant prevalence over time, albeit with some minor fluctuations ($\pm$2% in prevalence). Notwithstanding this, Twitter feeds from Europe showed a drastic reduction over time in Theme 1 (Community impact of loneliness during COVID-19), corresponding with a noticeable rise during this time in Theme 3 (Mental health effect of loneliness during COVID-19). Fig. 4 shows the variations in the prevalence of the 3 themes across the number of followers of the Twitter users. Theme 1 (Community impact of loneliness during COVID-19) did not vary significantly ($p = 0.273$) regardless of the number of followers of the Twitter users. In contrast, Theme 2 (Social distancing during COVID-19 and its effects on loneliness) was more commonly posted by less influential users ($p < 0.001$), while Theme 3 (Mental health effect of loneliness during COVID-19) was more frequently talked about by highly influential users ($p < 0.001$).

4. Discussion

This study adopted a novel approach – using a social media platform – to harness close-to-real-time public sentiments related to loneliness during the COVID-19 pandemic. It provided an alternative avenue to gather ground-level data on loneliness, especially during a time when traditional research methodologies can be restricted by social distancing measures. Twitter feeds related to loneliness and COVID-19 were posted by individuals across different parts of the world, of which 3 key themes could be identified, namely: (1) Community impact of loneliness during COVID-19; (2) Social distancing during COVID-19 and its effects on loneliness; and (3) Mental health effect of loneliness during COVID-19. The 3 themes demonstrated temporal variations as the COVID-19 pandemic evolved. Particularly in Europe, Twitter feeds related to the community impact of loneliness showed a drastic reduction over time, with a corresponding rise in posts related to the Mental health issues of loneliness during the same period. The themes also varied across the number of followers of the Twitter users, with highly influential users more likely to talk about mental health issues related to loneliness, and less likely to talk about issues related to quarantine and loneliness.

The findings from this study provided some evidence to support the multidimensional construct of loneliness, and that different themes and topics may plausibly be identified from a broad construct of 'loneliness'. In much of the prior literature (Blazer, 1982; Boss et al., 2015; Chang et al., 2017; Erzen and Çikrikci, 2018; Hackett et al., 2012; Heidari Gorji et al., 2019; Holt-Lunstad et al., 2010, 2015; Pinquart and Sorensen, 2001; Tanskanen and Anttila, 2016; Valtorta et al., 2016), loneliness has been conceptualized as a singular, unidimensional construct. Commonly used measurement tools, such as the UCLA loneliness scale, have often also captured loneliness as a single dimension (Neto, 2014; Xu et al., 2018). However, such an assumption may not be a true reflection of the experience of loneliness. As early as 1973, Weiss (Weiss, 1973) argued that loneliness consisted of social aspect (i.e. inadequacies in the size of the social network) and emotional aspect (i.e. absence of intimate relationships). This notion was then expanded on by many other studies exploring the multidimensionality of loneliness as well as the implications of the different dimensions (Dahlberg and McKee, 2014; DiTommaso and Spinner, 1997; Goossens et al., 2009; Russell et al., 1984). Most recently, one study by Hyland et al. (2019) examined the experience of loneliness among a nationally representative sample of 1839

adults in USA, and supported the use of the dimensions of loneliness proposed by Weiss (i.e. social and emotional aspects) (Weiss, 1973). In particular, Hyland et al. showed that the different dimensions were associated with unique risk factors, with the true prevalence of loneliness tending to be underestimated when the different dimensions were not taken into account.

The findings from this study may have implications on social policies related to loneliness during large-scale health crises, such as during the current COVID-19 pandemic. Previous studies during similar pandemics such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) largely focused on well-established psychological issues such as post-traumatic stress disorder and anxiety (Hawryluck et al., 2004; Jeong et al., 2016), with only minimal attention on the issue of loneliness (Lin et al., 2010; Mok et al., 2005). Thus far, there has already been early reports on the rising prevalence of loneliness during the COVID-19 pandemic, especially with the widespread practice of quarantine and social distancing during this pandemic (Banerjee and Rai, 2020). Given the known adverse effects of loneliness (Blazer, 1982; Boss et al., 2015; Chang et al., 2017; Erzen and Çikrikci, 2018; Hackett et al., 2012; Heidari Gorji et al., 2019; Holt-Lunstad et al., 2010, 2015; Valtorta et al., 2016), this may be an area that may require further attention by policymakers. In particular, the use of close-to-real-time data (such as those from social media) can be especially pertinent to inform policymakers regarding specific loneliness-related sentiments, given that the various themes of loneliness can vary over time as seen in this study. Potentially, such data may provide a ground-up approach in designing social policies related to loneliness, such as by recommending coping strategies that are already commonly employed in the community. This suggestion is not inconsistent with findings from recent studies that examined mental health-related behaviours and topics discussed in online health communities such as on Reddit (Low et al., 2020; Park et al., 2018). In particular, these recent studies demonstrated the possibility of identifying themes and high-risk features from online posts to inform further mental health interventions. Using the findings from this study by way of example, some of the coping strategies that may be considered include maintaining hope during difficult times (Topic 31), maintaining social connections using alternative means such as the digital technology (Topic 8), and coping with loneliness through creative arts and writings (Topic 28 and 33). Beyond just providing data on loneliness, social media may also play a role in addressing the issue of loneliness during the pandemic. As seen in the findings of this study, social medial influencers may potentially be recruited to raise awareness on loneliness and its associated mental health implications. Given the amount of influence that they already command in the virtual world, the positive impact these social media influencers can have on their followers is huge and far-reaching. Seeing someone they respect or adore emphasizing the importance of addressing loneliness may lead to a more impressionable memory, and possibly give more people the impetus to take an active role towards addressing this mental health issue.

The findings can also have research implications. Inasmuch as social media demonstrated the potential as an alternative data source for health and social science research, future studies may still be needed to demonstrate that sentiments on social media correspond sufficiently to ground-level opinions and may be used as a reliable alternative in obtaining close-to-real-time data in the community. For example, future researchers may consider demonstrating the correlation of social media posts to external data (such as to a manually-administered loneliness scale among subgroups of social media users, or to nationally-representative data on loneliness). Notably, in the presence of external data from social media users (such as data from manually-administered loneliness scale, or data from manual annotation on loneliness of each social media post), the free-text from social media can also be trained – using machine learning models – to identify social media users who have high levels of loneliness and may possibly benefit from further intervention. Such predictive approach is not dissimilar to a recent study by
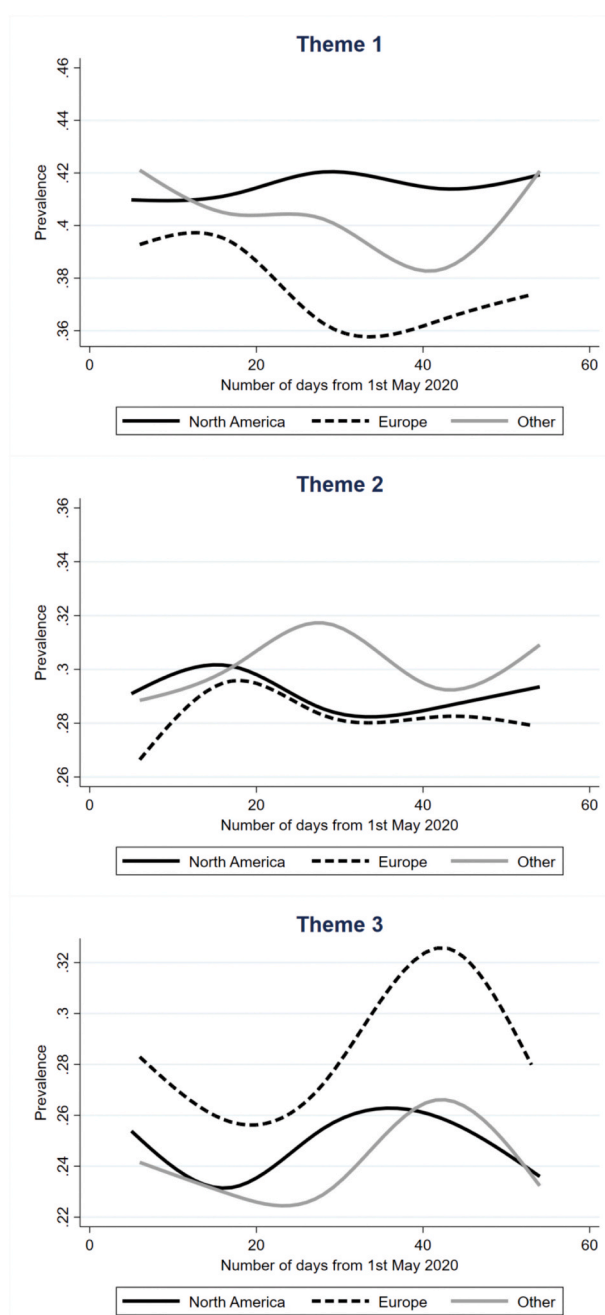

Fig. 3. Variations in the prevalence of the three themes, stratified by the continent of origin of the Twitter feeds.

Ji et al. (2018) which demonstrated the effectiveness of supervised machine learning model to accurately predict suicidal ideations and intentions from the online texts of social media users.

The findings of this study should be considered in light of its limitations. First, we only focused on Twitter feeds, as data on Twitter are more accessible than those on the other available social media. Keeping this in mind, the findings may not necessarily represent users in other social media, or those without access to technology. Second, we only included Twitter feeds that were posted in English, due to the practical challenges in analysing different languages together. Hence, the findings may be more representative of English-speaking populations. Third, many of the Twitter feeds did not have location data, which limited the analysis on geographical comparisons. Fourth, although a text-mining
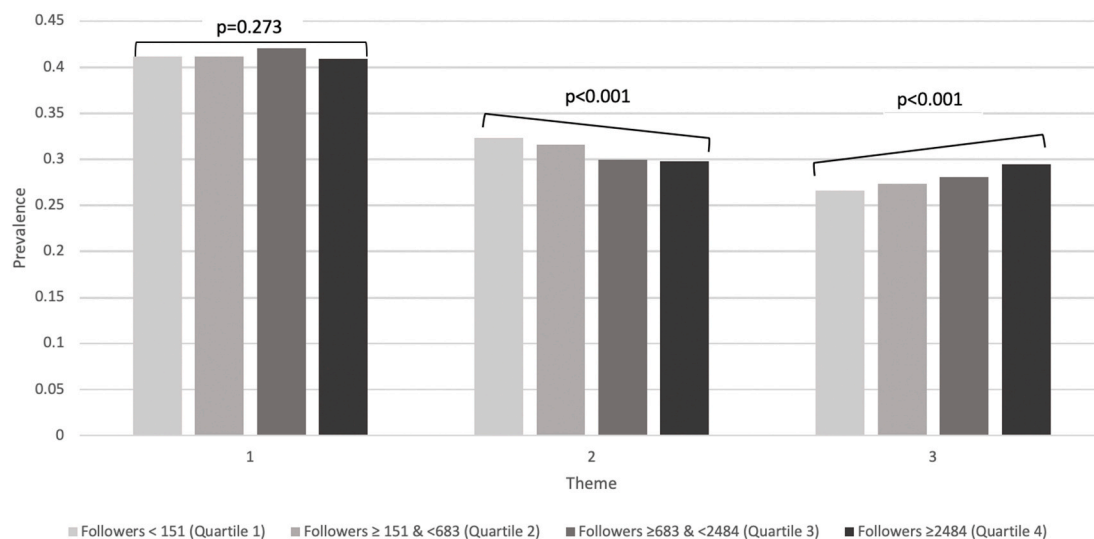
Fig. 4. Variations in the prevalence of the three themes, stratified by the number of followers of the Twitter users. The p-values were based on Kruskal-Wallis test.

approach allows for the analysis of large volumes of free-text data on Twitter, this approach is mainly based on probability and may not necessarily be as accurate as manually conducted thematic analysis.

In conclusion, this study provided a snapshot of loneliness-related sentiments and possible coping strategies that were employed during the COVID-19 pandemic. The findings suggest the multidimensionality of loneliness, highlight the potential usefulness of social media as an alternative platform to keep tabs on evolving mental health issues in the community, as well as provide inspiration for potential interventions to address novel problems, such as the issue of loneliness during COVID-19 pandemic. Future initiatives should build upon this study's findings and look into whether the coping strategies currently employed in the community can benefit the wider population and whether social media influencers can have a potential impact on loneliness. More effort can also be spent on examining the reliability of social media data as an alternative way of obtaining close-to-real-time feedbacks on ground-level sentiments, as well as the utility of social media data to predict individuals who may potentially benefit from further interventions related to the issue of loneliness.

Author statement

Study concept and design: T.M. Liew.
Literature review: J.X. Koh.
Analyses of data: T.M. Liew.
Interpretation of data: T.M. Liew and J.X. Koh.
Drafting of the manuscript: J.X. Koh and T.M. Liew.
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Declaration of competing interest

No conflict of interests declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.11.015.

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