Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Short communication

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

Jing Xuan Koh a,b,1, Tau Ming Liew a,c,*,1

a Department of Psychiatry, Singapore General Hospital, Singapore
b Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore
c Saw Swee Hock School of Public Health, National University of Singapore, Singapore

ARTICLE INFO

Keywords:
Social media
Loneliness
COVID-19
Topic modeling
Natural Language Processing
Mental health
Twitter

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 (Bos 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).

* Corresponding author. Department of Psychiatry, Singapore General Hospital, Outram Road, 169608, Singapore.
E-mail addresses: liew.tau.ming@singhealth.com.sg, ephltm@nus.edu.sg (T.M. Liew).
1 These authors contributed equally to this work and should be considered as joint first authors.

https://doi.org/10.1016/j.jpsychires.2020.11.015
Received 16 September 2020; Received in revised form 25 October 2020; Accepted 5 November 2020
Available online 7 November 2020
0022-3956/© 2020 Elsevier Ltd. All rights reserved.
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 free-text. 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 text-mining 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 best-practices (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 reduced 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
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 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) | “heartbeat 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.” | 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’”                     | 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 of liners 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.” | 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?” | 2.0            |
|       |                                                                                   | i’ll show you rain                                                                                                              |                |
|       |                                                                                   | i’ll show you heartbreak                                                                                                         |                |
|       |                                                                                   | i’ll show you lonely, a sorrow in darkness … … “                                 |                |
|       |                                                                                   | “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            |
|       |                                                                                   | “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            |
|       |                                                                                   | “… all shops are closed at this hour coz fuck u fucking fuck covid19. i’m just a shitfaced lonely man who wants his broke ass comfort food.” | 3.8            |
|       |                                                                                   | “how does it feel to be lonely?”                                                                                               | 3.7            |
|       |                                                                                   | 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 heights our urgency to treat loneliness.” |                |
|       |                                                                                   | “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            |
|       |                                                                                   | “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            |
|       |                                                                                   | “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            |
|       |                                                                                   | “a new befriending service will match a covid19 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            |
|       |                                                                                   | “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            |
|       |                                                                                   | “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            |
| Topic 13: Difference between social distancing and social isolation (isolation, social, distance, learn, lead) | |
| Topic 30: Desire to be able to meet with family and friends (take, also, much, back, away) | |
| Topic 11: Available community services to help reduce loneliness during isolation (help, via, call, can, good) | |
| Topic 22: Interacting with others help reduce loneliness for children and elderly (child, senior, other, tackle, cope) | |
| Topic 25: Frustration stemming from loneliness (even, right, start, never, now) | |

(continued on next page)
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%).

The 3 themes demonstrated temporal variations as the COVID-19 pandemic evolved. Particularly in Europe, Twitter feeds related to the coronavirus crisis 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 Çiçekci, 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 (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
The importance of addressing loneliness may lead to a more impressionable and far-reaching. Seeing someone they respect or adore emphasizing the particular, these recent studies demonstrated the possibility of identifying health-related behaviors and topics discussed in online health communities such as on Reddit (Low et al., 2020; Park et al., 2018). In particular, the 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 behaviors 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 media 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 post sentiments, with 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 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...
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.
Critical revision of the manuscript: T.M. Liew.
Study supervision: T.M. Liew.

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.
James, G., Witten, D., Hastie, T., Tibshirani, R., 2013. An Introduction to Statistical Learning. Springer.

Jeong, H., Yim, H.W., Song, Y.J., Ki, M., Min, J.A., Cho, J., Chae, J.H., 2016. Mental health status of people isolated due to Middle East Respiratory Syndrome. Epidemiol Health 38, e2016048.

Ji, S., Yu, C.P., Fung, S.-f., Pan, S., Long, G., 2018. Supervised learning for suicidal ideation detection in online user content. Complexity 2018, 6157249.

Kearney, M., 2019. rtweet: collecting and analyzing Twitter data. Journal of Open Source Software 4 (42), 1829.

Kenneth Benoit, A.M.. European Research Council, spacyr: an R wrapper for spaCy. https://spacyr.quanteda.io/. Accessed 4 August 2020.

Lin, E.C., Peng, Y.C., Tsai, J.C., 2010. Lessons learned from the anti-SARS quarantine experience in a hospital-based fever screening station in Taiwan. Am. J. Infect. Contr. 38 (4), 302–307.

Low, D.M., Rumker, L., Talkar, T., Torous, J., Cecchi, G., Ghosh, S.S., 2020. Natural Language processing reveals vulnerable mental health support groups and heightened health anxiety on Reddit during COVID-19: observational study. J. Med. Internet Res. 22 (10), e22635.

Mimno, D., Lee, M., 2014. Low-dimensional embeddings for interpretable anchor-based topic inference. In: Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP), pp. 1319–1328.

Mok, E., Chung, B.P., Chung, J.W., Wong, T.K., 2005. An exploratory study of nurses suffering from severe acute respiratory syndrome (SARS). Int. J. Nurs. Pract. 11 (4), 150–160.

Murnane, K., March 3, 2018. Which social media platform is the most popular in the US? https://www.forbes.com/sites/kevinmurnane/2018/03/03/which-social-media-platform-is-the-most-popular-in-the-us/#ebafcbab1e4. Accessed August 31 2020.

Neto, F., 2014. Psychometric analysis of the short-form UCLA Loneliness Scale (ULS-6) in older adults. Eur. J. Ageing 11 (4), 313–319.

Ong, A.D., Uchino, B.N., Wethington, E., 2016. Loneliness and health in older adults: a mini-review and synthesis. Gerontology 62 (4), 443–449.

Park, A., Conway, M., Chen, A.T., 2018. Examining thematic similarity, difference, and membership in three online mental health communities from Reddit: a text mining and visualization approach. Comput. Hum. Behav. 78, 98–112.

Pinquart, M., Sörensen, S., 2001. Influences on loneliness in older adults: a meta-analysis. Basic Appl. Soc. Psychol. 23 (4), 245–266.

Roberts, M.E., Stewart, B.M., Tingley, D., 2019. Stm: an R package for structural topic models. Journal of Statistical Software 91 (2), 40.

Russell, D., Catriona, C.E., Rose, J., Yusko, K., 1984. Social and emotional loneliness: an examination of Weiss’s typology of loneliness. J. Pers. Soc. Psychol. 46 (6), 1313–1321.

Tanskanen, J., Anttila, T., 2016. A prospective study of social isolation, loneliness, and mortality in Finland. Am. J. Publ. Health 106 (11), 2042–2048.

Torales, J., O Higgins, M., Castaldelli-Maia, J.M., Ventriglio, A., 2020. The outbreak of COVID-19 coronavirus and its impact on global mental health. Int. J. Soc. Psychiatr. 66 (4), 317–320.

Valtorta, N.K., Kanaan, M., Gilbody, S., Ronzi, S., Hanratty, B., 2016. Loneliness and social isolation as risk factors for coronary heart disease and stroke: systematic review and meta-analysis of longitudinal observational studies. Heart 102 (13), 1009–1016.

Victor, C.R., Scambler, S.J., Bowling, A.N.N., Bond, J., 2005. The Prevalence of, and Risk Factors for, Loneliness in Later Life: a Survey of Older People in Great Britain.

Weiss, R., 1973. Loneliness: the experience of emotional and social isolation. https://mitpress.mit.edu/books/loneliness2020.

Xu, S., Qiu, D., Hahne, J., Zhao, M., Hu, M., 2018. Psychometric properties of the short-form UCLA Loneliness Scale (ULS-8) among Chinese adolescents. Medicine (Baltimi.) 97 (38), e12371.

YouGov, 2019. The most popular social networks in the UK. https://yougov.co.uk/ratings/technology/popularity/social-networks/all. Accessed August 31 2020.