Modern Senicide in the Face of a Pandemic:

An Examination of Public Discourse and Sentiment about Older Adults and COVID-19

Using Machine Learning.

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Authors' contributions

X. X. conceptualized the study, directed data analysis, and drafted the manuscript. X. L. conducted supervised machine learning, topic modeling, and sentiment analysis. A. H. provided critical feedback for the study, wrote the initial programming codes for data analysis, and created visualizations. X. J. provided the second data source and data processing codes. Y. S. and P. L. assisted data analysis and article formatting. Z. W. provided critical feedback for the study and conducted a part of statistical analyses.

Conflict of interest

No disclosure.

ABSTRACT

Objectives: This study examined public discourse and sentiment regarding older adults and COVID-19 on social media and assessed the extent of ageism in public discourse.

Methods: Twitter data (N=82,893) related to both older adults and COVID-19 and dated from January 23 to May 20, 2020, were analyzed. We used a combination of data science methods (including Linguistic Inquiry and Word Count, supervised machine learning, topic modeling, and sentiment analysis), qualitative thematic analysis, and conventional statistics.

Results: The most common category in the coded tweets was "personal opinions" (66.2%), followed by "informative" (24.7%), "jokes/ridicule" (4.8%), and "personal experiences" (4.3%). The daily average of ageist content was 18%, with the highest of 52.8% on March 11, 2020. Specifically, more than one in ten (11.5%) tweets implied that the life of older adults is less valuable or downplayed the pandemic because it mostly harms older adults. A small proportion (4.6%) explicitly supported the idea of just isolating older adults. Almost three-quarters (72.9%) within "jokes/ridicule" targeted older adults, half of which were "death jokes." Also, 14 themes were extracted, such as perceptions of lockdown and risk. A bivariate Granger causality test suggested that informative tweets regarding at-risk populations increased the prevalence of tweets that downplayed the pandemic.

Discussion: Ageist content in the context of COVID-19 was prevalent on Twitter. Information about COVID-19 on Twitter influenced public perceptions of risk and acceptable ways of controlling the pandemic. Public education on the risk of severe illness is needed to correct misperceptions.

Keywords: COVID-19, ageism, machine learning, social media, Twitter

INTRODUCTION

Senicide is the killing of older persons, or their abandonment to death. The practice of senicide existed in many cultures. Senicide is an extreme form of ageism, defined as stereotypes, prejudice, and discrimination against older adults (Ayalon & Tesch-Römer, 2018). Ageism can be positive and negative, but growing older today is often associated with deterioration, vulnerability, and morbidity, and older adults are perceived as a homogenous group that is mostly sick, dependent, or incompetent. Extensive research has shown the harmful effects of ageism in society on the physical, cognitive, and mental health of older adults (Chang et al., 2020). For instance, in experimental studies, older adults had worse memory performance after brief exposure to negative age stereotypes than when exposed to positive stereotypes (Lee & Lee, 2019). These societal ageist attitudes have also seeped into the health care system, affecting clinical decision-making and causing suboptimal care and clinical outcomes among older adults (Wyman, Shiovitz-Ezra, & Bengel, 2018). Contemporary theoretical perspectives on the origins of ageism point to a zero-sum mentality, where people draw a line between older adults and the "rest of us" without realizing that we will all grow old one day (Ayalon & Tesch-Römer, 2018). Contrary to the popular zero-sum beliefs, ageism hurts everyone and imposes a hefty societal burden. Ageism costs the U.S. health care system an estimated $63 billion and the U.S. economy $850 billion a year (Accius & Suh, 2020; Levy, Slade, Chang, Kannoth, & Wang, 2020). Nevertheless, ageism is entrenched in our society and often goes unchallenged, making it an insidious threat to public health.

The intergroup threat theory suggests that ageism may intensify at times of scarce resources due to the increased threats perceived by the "rest of us" (Stephan & Stephan, 2017). Existing evidence suggests that ageism accentuates during an economic crisis, which can

backfire and exacerbate the crisis (Stypińska & Nikander, 2018). However, the evidence is scarce regarding the extent of ageism during a public health crisis. The COVID-19 outbreak poses one of the most significant public health crises in modern history. It has also sparked an evolving global economic crisis and a ripple effect on every aspect of human life. Although much is still unknown, early data from China emphasized age as a significant risk factor for COVID-19 mortality (Zhou et al., 2020). Data from Italy showed a case-fatality rate of 20% for persons aged over 80, whereas 0 deaths occurred in those younger than 30 (Onder, Rezza, & Brusaferro, 2020). These data, albeit valuable, may have inadvertently contributed to the portrayal of COVID-19 as the "problem of older adults" and the spread of the misperception that it mainly affects older adults, despite clear evidence documenting the burden of severe illness among younger persons (Bialek et al., 2020). This misperception had led to "corona parties," where young people celebrated the COVID-19 outbreak and purposely tried to infect themselves, in the U.S., Germany, and other countries (Ayalon, 2020). This misperception, fueled by unprecedented public health and economic crisis, has also resulted in ageist policies and public messages in pandemic responses. Critics of government response to COVID-19 have expressed that the mismanagement of COVID-19 in western countries is akin to the practice of senicide (Ferguson, 2020).

The present study aims to examine public discourse and sentiment regarding older adults and COVID-19 on Twitter and to assess the extent of ageism in public discourse. Twitter is well suited for gauging public sentiment in an evolving crisis because it provides fast news and allows instant reactions from users. To our knowledge, this is the first large-scale analysis of public discourse and sentiment regarding older adults in the context of COVID-19.

Methods

Data

Tweets used in this study came from two resources. Twitter Decahose, a compilation of a 10% random sample of all tweets, was made available to the University of Michigan. Keyword searches of terms related to both older adults ("older people," "old people," "older adults," "elderly," "senior citizens," "baby boomer," "boomers") and COVID-19 ("COVID19," "coronavirus," "corona," "ncov," "pandemic," "sars cov 2," "hcov 19," "virus," "quarantine," "lockdown," "stay at home," and "social distancing") yielded 97,009 tweets published in English and dated from February 1 to May 20, 2020. A second data source, from a co-author who routinely collected tweets related to COVID-19 through the free Streaming API, provided 123,564 relevant tweets dated between January 23 and April 30, 2020 (Xue et al., 2020). The two data sources had a small degree of overlap (3.2% of all unduplicated tweets). We processed the text field of tweets, changing words into lowercase, removing hyperlinks, "@" signs for usernames, and non-English characters, and then removed duplicates. The final study sample included 82,893 unique tweets. This study involved secondary analysis of public data and was not regulated as human subjects research by the University of Michigan Institution Review Board. To preserve source anonymity, we did not publish direct quotes or usernames.

Data analysis

We used a combination of data science methods, qualitative thematic analysis, and conventional statistics to provide a comprehensive analysis of public discourse and sentiment. The specific data science methods involved Linguistic Inquiry and Word Count (LIWC), topic classification (supervised machine learning), topic modeling (unsupervised machine learning), and sentiment analysis. These data science methods provided an efficient way to classify tweets and extract latent topics in public discourse. Topic modeling following topic classification

allowed the identification of latent topics that were easier and more intuitive to interpret. Qualitative thematic analysis, which is frequently used in combination with topic modeling, enabled us to contextualize the latent topics from machine learning, extract themes, and assign meaning to each theme. Finally, sentiment analysis complements the previously mentioned methods in understanding public discourse by uncovering the emotions and feelings in tweets.

LIWC. We counted the frequency of specific phrases of interest and identified top words within the body of all tweets in our data, after removing stop words (e.g., "the," "is," "at"). Top words were visualized using word clouds.

Topic classification. We used supervised machine learning (ML) to classify tweets related to both older adults and COVID-19 into four mutually exclusive categories adapted from previous studies (Jimenez-Sotomayor, Gomez-Moreno, & Soto-Perez-de-Celis, 2020; Oscar et al., 2017) including (1) informative, (2) personal experiences, (3) personal opinions, and (4) jokes/ridicule (referred to as the main classifier).

To identify ageist content, we rated each tweet dichotomously (yes or no) on three questions (referred to as attributes): (1) Is this tweet implying that the life of older adults is less valuable or a reasonable sacrifice, or downplaying the pandemic because it mostly affects older adults? (2) Is this tweet explicitly supporting the idea of just isolating older adults and other high-risk groups, while the rest of the country goes about its business? (3) For tweets classified as jokes/ridicule, is this joke/ridicule targeting older adults?

Two researchers manually classified a random subset of tweets (n=8453 or 10.2%). The inter-rater reliability kappa statistic of manual coding on a random subset of training data (n=200) ranged from 0.85 to 0.98, suggesting a high chance-corrected inter-rater agreement. We built an ML algorithm to assign the category and attributes automatically to the remaining tweets

in the dataset. We converted the tweets to term frequency-inverse document frequency (TF-IDF) features (Ramos, 2003) and split the labeled dataset into a training set (90%) and a testing set (10%). For each classification task, we trained three ML models, including Logistic Regression (Kleinbaum, Dietz, Gail, Klein, & Klein, 2002), Linear Support Vector Classifier (SVC) (Gunn, 1998), and Random Forest (Breiman, 2001). We selected the model with the highest accuracy on the testing set. Accuracy was 0.79 for the main classifier and ranged from 0.76 to 0.97 for the three attributes.

Topic modeling and qualitative thematic analysis. After tweets were classified into four categories of the main classifier, we used topic modeling to extract underlying themes. Latent Dirichlet Allocation (LDA) is an example of topic modeling that identifies latent topics, clusters of words that frequently co-occur, in a corpus through probabilistic assignments of words into topics. We ran different LDA experiments, varying the number of topics, and selected the model based on the highest coherence value score (Mimno, Wallach, Talley, Leenders, & McCallum, 2011). We contextualized LDA outputs using qualitative thematic analysis. This process involved interpreting the top words within each estimated topic, reviewing a random sample of tweets grouped by the most prevalent topic, assigning topic meanings and labels, and inductively developing themes (Braun & Clarke, 2006).

Sentiment analysis. The Lexicon-based approach calculates sentiment from the semantic orientation of words based on an external dictionary of words and their sentiment value. The NRC Emotion Lexicon is a list of words and their associations with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy, and disgust) and two sentiments (negative and positive) (Mohammad & Turney, 2013). After matching words in the processed tweets (i.e., removing articles, pronouns, and prepositions) with the NRC Lexicon, we retained the dominant

emotion (i.e., the highest matching count) for each tweet for ease of interpretation.

Trend analysis. Because our data covered a relatively long period since the COVID-19 outbreak, we used time-series graphs to describe changes in dominant themes in public discourse and sentiment as the pandemic unfolded. A bivariate Granger causality test (Granger, 1969) was used to explore the interconnections between trends in selected theme topics.

Results

Top words in public discourse regarding older adults and COVID-19

Of the 82,629 tweets, "elderly" was the most used term referring to older adults (68.2%), followed by "older people" or "older adults" (12%), "old people" (10.3%), "baby boomers" or "boomers" (4.9%), and "senior citizens" (4.5%). Other than phrases directly related to older adults and COVID-19, top words appeared in the tweets included "stay home" or "home," "lockdown," "care home" or "nursing home," and "death" (Figure 1a).

Themes in public discourse regarding older adults and COVID-19

The most common category in the coded tweets (N=82,893) was "personal opinions" (66.2%), followed by "informative" (24.7%), "jokes/ridicule" (4.8%), and "personal experiences" (4.3%). Representative tweets for each category are in Table 1.

The LDA topic modeling generated 24 latent topics, from which we extracted 14 themes using a qualitative thematic analysis. Table 2 shows theme labels, top words, and representative tweets. Themes in the "personal opinions" category involved "to lock down or not to lock down" (31.9%), "long-term care facilities" (31.7%), "perception of risk" (20%), and "perception of pandemic severity" (16.4%). A manual review of thousands of sample tweets uncovered diverse and often polarizing perspectives regarding disease severity, risk, and pandemic control measures. Tweets related to long-term care (LTC) facilities, however, appeared to show a

consensus concerning the death toll and the government's handling of COVID-19 in LTC facilities, for example, in New York (Young, 2020). Most of these tweets appeared to come from users in the United States (identified by the phrase "nursing home") and the U.K. (identified by the phrases "care home" and "NHS").

Informative tweets included news, COVID-19 facts, study findings, and public announcements. Dominant themes were "mental health toll" (39.3%), "basic needs" (27.5%), "LTC facilities" (14.7%), "at-risk populations" (10.1%), and "pandemic updates" (8.4%).

The most prevalent theme in the "jokes/ridicule" category was "intergenerational conflict" (53%). Most of these tweets exploited the perceived differences in perspectives regarding a range of issues, including climate change, health care, social security, affordable housing, and the general election, as well as attitudes and practices toward COVID-19 across birth cohorts, especially between Baby Boomers and Millennials. Tweets related to "aging stereotypes" (25%) often played on stereotypes of older adults in everyday life (e.g., "older people are racist") and in the pandemic (e.g., "older people do not follow social distancing"). The remaining theme involved "quarantine boomer" jokes (21.9%).

"Personal experiences" involved a wide range of personal accounts of events, including events relevant to "family and friends" (58.2%) and those related to "neighbors" (41.8%). Both themes had content related to personal losses due to COVID-19.

Ageist content in public discourse regarding older adults and COVID-19

More than one in ten (11.5% or n=9495) tweets in the dataset implied that the life of older adults is less valuable or downplayed the pandemic because it mostly harms older adults (see Table 1 for representative tweets). Top words within these tweets, other than those related to older adults and COVID-10, were "kill," "death," "quarantine," "compromised immune,"

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"young," "healthy," "life," "economy," and "back [to] work." (Figure 1b). The proportion of these tweets was the highest within "jokes/ridicule" (45%), followed by "personal opinions" (13.8%), "personal experiences" (0.9%), and "informative" (0.5%).

A small proportion of tweets (4.6%) explicitly supported the idea of just isolating older adults and other high-risk groups (see Table 1 for representative tweets). Nearly all (99%) of these tweets were "personal opinions." Top words within these tweets, other than those related to older adults and COVID-10, were "quarantine," "work," "sick," "stay," "back," "healthy," "economy," "open," "herd," and "life." (Supplemental Figure 1S)

Almost three-quarters of tweets (72.9% or n=2904) within "jokes/ridicule" targeted older adults. Slightly under half of these tweets (45%) were "death jokes" that made light of the pandemic because it disproportionally affects older adults. COVID-19 was called many names: the "boomer remover" for disproportionally affecting the Baby Boomer generation; the "election year virus" for "hopefully wiping out enough old people" to influence the general election, which perpetuates the stereotype that older adults are a politically homogenous group; and the "karma virus" for "getting back at" older adults who were blamed for causing many of the problems faced today, such as climate change.

Combining all three attributes described above, 16.4% of tweets in our data had ageist content, with most of them implying that the life of older adults is less valuable or downplayed the pandemic. The daily average of all ageist content was 18%, with the highest of 52.8% on March 11, 2020.

Trends in themes and ageist content and their interconnections

The prevalence of attributes and themes changed over time. The proportion of tweets that downplayed the pandemic had early peaks between late January and early February (e.g., 33.3%

on January 29 and 28.6% on February 6) and a second peak on February 27 (25.7%). A final round of peaks occurred between March 8 and 13, with a daily average of 27.6% and the highest of 33.1% on March 11, followed by an approximate flat line with a daily average of 9% for the remainder of the study period. These trends appeared to track the trends of "at-risk populations" topics within "informative" tweets. A bivariate Granger causality test (Granger, 1969) suggested that past informative tweets regarding at-risk populations increased the prevalence of tweets that downplayed the pandemic, and this Granger causality link was the largest at the lag of one day (beta_1=0.44, se=0.094, p<.001). Informative tweets related to pandemic updates also significantly (p<.05) predicted tweets that downplayed the pandemic with lags of up to 7 days (Figure 2).

Tweets that supported isolating older adults were rare in February but became more prevalent, with a peak between April 17 (10.4%) and 26th (8.6%). The Granger causality tests linking these trends and the trends within "informative" tweets were not significant at p<.05 (Figure 2).

Trends in several theme topics within "personal opinions" significantly tracked those within "informative" tweets. A complete description of these interconnections and trend graphs are available online (Figure 2S-5S). For instance, trends in LTC-related informative tweets had a significant Granger causal link with LTC-related tweets within "personal opinions." Past informative tweets related to "pandemic updates" and "long-term care facilities" predicted trends in lockdown related topics within "personal opinions."

Sentiment in public discourse regarding older adults and COVID-19

NRC Lexicon emotions and sentiments changed over time within some themes (see Supplemental Files, Figure 6S-19S). For instance, "fear" and "sadness" were the most prevalent

emotions in the lockdown related theme within "personal opinions." Over time, "anticipation" rose and peaked between April 12 and 22. "Fear," "sadness," "trust," and "anticipation" were the most prevalent emotions within "informative tweets" related to "at-risk populations"; the relative composition of these emotions appeared to be stable over time (Figure 3).

Discussion

This study provided the first large-scale analysis of public discourse and sentiment regarding older adults in COVID-19 on Twitter, covering 119 days of the coronavirus outbreak since January 23, 2020. Our analytical approach involved novel applications of artificial intelligence methods to study age discrimination, accompanied by qualitative thematic analysis and traditional statistical methods. Applying these methods, we can continue to track public attitudes towards older adults in COVID-19 and beyond and identify potentially effective strategies to reduce ageism. Combining all three tweet attributes, 16.4% of tweets in our data had ageist content, with most of them hinting elements of senicide. The daily average of ageist content was 18%, with the highest of 52.8% on March 11, 2020, which coincided with when the World Health Organization declared the COVID-19 a pandemic. Study findings also suggested a relatively high level of "trust" expressed in tweets and that information about COVID-19 on Twitter likely influenced public perceptions of risk and acceptable ways of controlling the pandemic relevant to the treatment of older adults.

Research regarding ageism on social media is scarce (Jimenez-Sotomayor et al., 2020; Levy, Chung, Bedford, & Navrazhina, 2014; Makita, Mas-Bleda, Stuart, & Thelwall, 2019; Oscar et al., 2017). A recent study manually coded 351 tweets relevant to older adults and COVID-19 posted between March 12 and 21, 2020 (Jimenez-Sotomayor et al., 2020). A quarter of these tweets had ageist content, either because they included jokes or ridicule targeting older

adults or because they downplayed the relevance of COVID-19. To compare our findings against the recent study, we examined all tweets in our data from the same 10-day period in March and applied a similar measure of ageist content by combining tweet attribute one and three. We found that 25.1% of all tweets during this time had ageist content, consistent with findings from the recent study. Several other studies, none relevant to COVID-19, also found pervasive ageist content on Twitter and Facebook (Levy et al., 2014; Makita et al., 2019; Oscar et al., 2017).

Extending beyond the descriptive findings from previous studies, we found a strong Granger causality linking past information about COVID-19 on Twitter to content containing elements of senicide. The proportion of tweets that implied the life of older adults is less valuable or downplayed the pandemic rose as quickly as one day after each increase in informative tweets related to COVID-19 risk factors. These findings provided evidence that more directly implicating social media as an online platform that reproduces and reinforces existing ageism in society than descriptive findings from previous studies.

An examination of top words in tweets revealed subtle forms of ageism, which are not as extreme as senicide but harmful, nonetheless. "Elderly" was the most commonly used term related to older adults in our data, which is often used negatively and associated with frailty, vulnerability, and senility (Makita et al., 2019). Besides, words such as "vulnerable," "immunocompromised," and "sick" often appear next to terms referring to older adults, whereas "young" and "healthy" appeared together. The words associated with vulnerability appeared both in tweets that showed apathy toward older adults and in tweets that advocated for the protection of older adults. Language choices are critical to social identities. Negative characterizations can perpetuate stereotypes toward older adults as a homogenous and devalued social group, which can lead to marginalization (Makita et al., 2019). Therefore, even in situations where older adults

might be at a disadvantaged position, such as in COVID-19, we should avoid terms that reinforce these stereotypes.

The COVID-19 pandemic has created a perfect storm for age discrimination. To begin with, COVID-19 seems to be "ageist," with an increased mortality rate with age (Onder et al., 2020; Zhou et al., 2020). Since the pandemic took hold, we have experienced significant disruptions to everyday life. Millions of people have lost their jobs, and a fear of a global economic recession increases by the day. The social, public health, and economic crises evolve against the backdrop of rapid population aging. By the 2030s, older adults are projected to outnumber children for the first time in U.S. history (U.S. Census Bureau, 2018). The unprecedented influx of older adults has raised concerns about the sustainability of social and economic development and ignited ongoing public debates about social policies for older adults (Bloom et al., 2015). At the center of the attention is the Baby Boomers, who have been blamed for a myriad of social problems and widely perceived as the generation that took their children's economic future, causing an intergenerational rift between the young and the old (Bristow, 2015). The increased intergenerational conflict, exemplified by the clash of Baby Boomers and Millennials, was evident in our data. More than half of the tweets classified as "jokes/ridicule" were related to the theme of "intergenerational conflicts." Many of these tweets exploited the rift between Baby Boomers and Millennials regarding a range of issues, such as climate change, health care, social security, affordable housing, and the 2020 presidential primary election. The COVID-19 crisis appeared to have intensified these generational divisions.

On a more positive note, we found tweets that demonstrated intergenerational solidarity and a keen awareness of ageism in the pandemic. For example, one tweet says, as paraphrased, "the 'elderly vulnerable' rhetoric in COVID-19 is patronizing and dangerous because it conjures

up an image of older adults as a homogeneous group who stay at home all the time anyway. Most older adults work, volunteer, and participate in our communities." Another tweet asked whether people would be just as anxious to end the lockdown if COVID-19 was killing children instead of older adults and called for everyone's patience, citing that every life is precious. Some tweets also used the #ageism to raise awareness.

A limitation of this study is the use of Twitter data. Twitter users represent segments of the U.S. and global population. To illustrate, Twitter users tend to be younger, with a median age of 40, better educated, and relatively wealthier compared with the general U.S. population (Wojcik & Hughes, 2019). Nevertheless, Twitter users as a group have mostly similar attitudes as the general population on a range of social and political issues (Wojcik & Hughes, 2019). Most Twitter users rarely tweet, and 80% of tweets come from the most prolific 10% of users (Wojcik & Hughes, 2019). Fake accounts and Twitter bots also exist. We mitigated these issues by removing exact and near-exact duplicates from our data.

Scholars have cautioned that the COVID-19 pandemic exposed and intensified ageism in our society, which contributed to potentially avoidable deaths (Fraser et al., 2020). Our findings suggest that while social media such as Twitter has reproduced ageism, its speed and influence can be leveraged to combat ageism for improved health equality and reduced societal cost. Moving forward, we must carefully craft public communications to avoid patronizing and stigmatizing terms related to older adults to correct overgeneralizations. Misperceptions of risk can create a false sense of security and noncompliance with public health measures (e.g., physical distancing) among younger people as the pandemic continues to threaten the lives of all ages. Public education is needed on the risk of severe illness to help people develop a more balanced view of risk for individuals across the lifespan. Correcting misperceptions of risk will

also promote intergenerational solidarity, by replacing the current narrative that "young people must practice physical distancing to protect older people" with "we are all in this together." Furthermore, disseminating stories that highlight the contribution of older adults in this pandemic and their value to the society, as well as examples of intergenerational solidarity, can help redress ethically questionable suggestions (e.g., rushing "herd immunity" and "quarantine" older adults). Older adults continue to contribute to society in many ways and represent a powerful force that drives economic growth and value. We must recognize their value, learn from past mistakes, and prevent the return of senicide to the modern world.

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Table 1

Classification of Tweets Related to COVID-19 and Older Adults (N=82,893)

Classification	N	%	Representative tweets
Personal opinions	54878	66.2	Individual species don't survive. Ecosystems survive. An ecosystem where the elderly parasitizes the young cannot survive. So the ecosystem throws out a virus and makes the whole system more livable.
			Every discussion of #Coronavirus I hear has some version of "It only kills old people." How can people be so casual about parents, grandparents, educators, nurses, doctors, thought leaders, and so much more? Modern Senicide.
Informative	20490	24.7	Stores offering dedicated shopping hours for seniors
			Tips for helping older adults stay connected during coronavirus isolation
Jokes/Ridicule	3986	4.8	Alexa, how much is the Western world saving in health care and pension costs with all the virus deaths among the elderly, and could that be an incentive for late response in the U.S. and the U.K.? But before you answer that, play … now.
			The coronavirus uniquely engineered itself to attack the elderly and leave the youth unscathed. It's the election year virus.

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Personal experiences	3539	4.3	My elderly uncle died of COVID19 recently. I hadn't seen him in many years, but he was a gentle, lovely man. His wife is in self-quarantine in a virus hotspot. I cannot imagine the grief and suffering. 😞💔
			My elderly neighbors let my dogs in their garden so they can watch them through the window during #lockdown 🐶 Daisy thinks their garden is much better than her own garden.
Implied that the life of older adults is less valuable or downplayed the pandemic	9495	11.5	No one is arguing that old people should die or be denied treatment. But we shouldn't trade millions of lives to try saving the very old and frail from a virus. It's like an elephant jumping off a cliff to avoid a mouse.
			The swine flu killed nearly 2000 children. The coronavirus pretty much only kills the elderly with underlying health issues. It will be no worse than a common cold. Besides, we will all be dead in 100 years.
Supporting the idea of isolating older adults only	3795	4.6	Quarantine the elderly, not the ones working, and let the young live again
			They say we can only have normalcy when most people are vaccinated. I think quarantine camps for old people is the correct way to go.

Note. Representative tweets were either a composite of multiple example tweets or an excerpt of a single tweet to preserve source anonymity.

Table 2

Themes from Latent Dirichlet Allocation and Qualitative Thematic Analysis, With A Collection of Top Words Used To Define The Theme And A Representative Tweet

Classification	Theme	%	Top words	Representative tweets
Personal opinions	to lock down, or not to lock down	31.9	stay home, lockdown, herd immunity, quarantine, high risk, everyone else, back to work, young healthy, vulnerable, protect	The elderly and those with underlying conditions should continue to stay home while everyone else goes back to work and gets herd immunity. You don't quarantine healthy people. We must stay at home to protect the elderly and vulnerable! The young may not die but can spread the virus to those at risk.
	perception of pandemic severity	16.4	older, death rate, mortality rate, immune system, young, healthy	The death rate of COVID19 is highest for elderly people whose immune system was already weak :) For the young and healthy, the chances of dying are extremely low. It is no more severe than the cold. So many people are downplaying #coronavirus, even "if"

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the mortality rate is low, you should take proper precautions and be responsible. It was said the mortality rate is higher in the elderly & compromised immune system. That could be your family or someone else.

perception of risk	20.0	underlying condition, underlying health, existing condition, health issue, sick, kill, child, social distancing	Most people contracting corona will have mild symptoms. Yes, it is more serious for the elderly or those with underlying conditions. But thankfully, children are not affected. The lord is moving among us.
			The virus should be taken more seriously. It isn't just killing the elderly. Also, not everyone knows if they have underlying health issues.
long-term care facilities	31.7	nursing home, care home, patient, death, many, hospital, back, lockdown, Cuomo, government, family	Most of these deaths happened at the nursing home. The government should make have makeshift hospitals to remove the elderly out of the nursing homes and test the workers in the homes. They should not have sent

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	member			patients from the hospital back to the nursing homes that were unprepared to care for sick patients.
Informative	basic needs	27.5	lockdown, help, home, vulnerable, food, need, service, support, meal	A church closed by the coronavirus has bounced back with their community and is now supplying homes of the elderly, isolated and vulnerable with basic foods, medicines, and friendship.
	at-risk populations	10.1	stay home, risk, live alone, pregnant women, disability, existing conditions	High-risk patients include the elderly, pregnant women, and those with serious symptoms or pre-existing health conditions like cancer and asthma, said Health Secretary. #COVID19
	pandemic updates	8.4	mortality, case, patient, shelter in place, tested positive, treatment	Latest Virus Mortality Rate: COVID-19: overall, 3.6% (15% in the elderly; 0.6% in younger patients). COVID2-SARS: 10% mortality but more contained spread. Influenza 0.1% case fatality.
	long-term care facilities	14.7	care home, home, death, patient, hospital, high risk	Breaking news in Holyoke, MA. Coronavirus kills nearly 70 at Massachusetts veterans' home. Investigations are

				ongoing as to why hospitals are transferring infected people to high-risk areas.
	mental health toll	39.3	lockdown, social distancing, mental health, social isolation, domestic violence, living alone, help	The helpline offers advice & support for #COVID19 & other issues that are coming up for older people at this time, including difficulties in relation to physical & mental health, loneliness, isolation, finance, safety, and housing.
Jokes/ridicule	intergenerational conflict	53.0	millennials, climate change, generation, kill, social security, lockdown, toilet paper	Coronavirus responses by generational cohort. Boomers: raid the supermarkets and buy toilet paper. Gen X: [forgotten]. Millennials: lmao how boomers feel about coronavirus is how we feel about climate change all the time. If it wipes out enough boomers, maybe we can have social security checks when we retire. Gen Z: Let's have a bunch of parties. Who wanna go to France with me for $30?
	"quarantine	21.9	quarantine, baby, another	Think about all those people who will get pregnant during

	boomers"		generation	this quarantine and have a bunch of babies. What should we call them? Quarantine boomers? Corona boomers? Baby boomer 2.0?
	aging stereotypes	25.0	social distancing, kill, stay at home, Trump	You call them social distancing protestors. I call them 'the Flu Klux Klan' or 'suicide boomers.'
Personal experiences	family and friends	58.2	elderly mother, parent, relative, family member, stay home, social distancing, quarantine, friend, nursing home, passed away	I am a caregiver for my elderly parents, and I moved in with them during the quarantine. We all stayed home. I leave the house for walks. #StayHome My elderly mother is in a nursing home, and they are in a soft lockdown. I could not visit her. The quarantine is hard. I have two elderly relatives who died this month from the coronavirus.
	neighbors	41.8	elderly neighbor, neighbor, elderly lady, take care, help, grocery store, shopping,	I just started an art project in lockdown, drawing my elderly neighbor while sitting 3 meters away and wearing a mask. This is my lovely neighbor Sam. He is

quarantine, passed away   isolated and not very mobile. He stopped driving, and

I've been helping him with grocery shopping.

Note. Phrases related to older adults and COVID19 often appeared as top words but were not shown in this table for ease of

interpretation. To preserve source anonymity, we presented either a composite of multiple example tweets or an excerpt of a single

tweet. Two representative tweets were shown for themes that contained more diverse perspectives.

Figure 1. Word cloud of top words. Panel (a) shows the top words in all tweets (N=82,893).

Panel (b) shows the top words in tweets that implied the life of older adults is less valuable or

downplayed the pandemic because it mostly harms older adults (N=9495). Terms related to older

adults and COVID-19 were removed from the word cloud.

Figure 2. Changes in the prevalence of tweet content related to older adults and COVID-19 from January 23 to May 20, 2020. The top panel shows changes in the proportion of tweets that implied the life older adults is less valuable, a reasonable sacrifice, or downplaying the pandemic because it mostly affects older adults (attribute 1) and changes in the proportion of tweets that explicitly supported the idea of just isolating older adults and other high-risk groups (attribute 2). The denominator was the total number of tweets for the day. The bottom panel shows changes in the proportion of tweets related to the theme of "at-risk populations" and tweets related to the theme of "pandemic updates" within "informational tweets." The denominator was the total number of informational tweets for that day. A bivariate Granger causality test suggested that the time series of "at-risk populations" had a significant Granger causal link with the time series of attribute one with a maximum lag of 7 days ($p<.001$); similarly, between "pandemic updates" and attribute one ($p<.05$). Tests linking the time series of attribute two and the time series of informational tweets were not statistically significant.

Figure 3. Changes in the prevalence of NRC emotions within tweets related to older adults and COVID-19 from January 23 to May 20, 2020. The top panel shows changes in the proportion of 8 NRC emotions in the lockdown related theme within "personal opinions." The bottom panel shows changes in NRC emotions within "informative tweets" related to "at-risk populations."
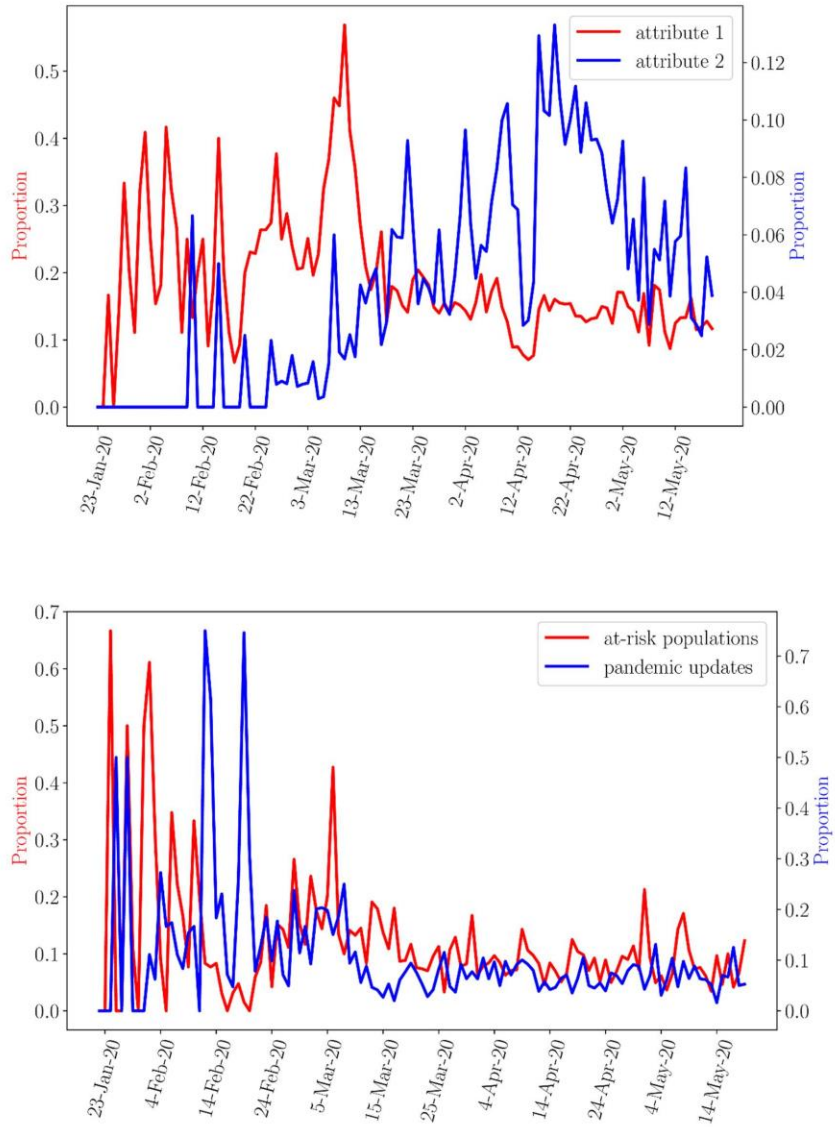
Figure 1

(a)

(b)

Figure 2

Figure 3