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# COVID-19 outlook in the United States of America: a data-driven thematic approach

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## 1. Introduction

Owing to the novelty of the coronavirus disease 2019/severe acute respiratory syndrome coronavirus 2 (COVID-19/SARS-COV-2) infection, researchers had earlier recommended careful surveillance to monitor the evolution, pathogenicity, and transmissibility of COVID-19 spread, but such warnings remained as buzzwords to many nations [1]. The United States of America, as a humanitarian and charitable country, has continued to play a central role in subduing the ongoing COVID-19 crisis, but America's leading humanitarian and health assistance response to combat COVID-19 did not exempt the country from the deadly coronavirus. As of May 27, 2020, the Johns Hopkins University of Medicine reported 967,585 total confirmed cases, 54,931 total deaths, and 5,441,079 total tests conducted. These statistics confirmed America as the epicenter of the COVID-19 pandemic. Despite the contention surrounding COVID-19, the US government has tried to "flatten the curve". However, the government's effort cannot be fully comprehended without examining the opinions of the American people, and the world in general, based on the Pandemic Intervals Framework (PIF) recommended by the Centers for Disease Control and Prevention (CDC). This organization categorized the influenza pandemic progression into six intervals of investigation, recognition, initiation, acceleration, deceleration, and preparation for future pandemic waves[1]. In between the prepandemic and pandemic intervals, there are positive, negative, and neutral reactions through social media. These online opinions call for further investigation so that the populace can have a

[1]Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD), 2016, Pandemic Intervals Framework (PIF), https://www.cdc.gov/flu/pandemic-resources/national-strategy/intervals-framework.html.

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proper understanding of behind-the-scene actions and reactions. At the time of writing this chapter, America has gone through the four stages of the proposed PIF and was working toward the deceleration stage. Some earlier studies focused on single and multiple countries in the context of COVID-19. Li et al. [1] examined the new COVID-19 transmission dynamics in China, Mohd and Wan [2] showcased public knowledge and communication behavior in Malaysia, Lohiniva et al. [3] assessed the risk perceptions of COVID-19 in Finland, and Moore et al. [4] investigated COVID-19 social distancing in the United States. Besides, studies examined the preparation and the vulnerability of the African countries for COVID-19 [5]. Although a group of countries' studies offer good information for comparative insight, this study focuses on a single country based on the argument of Pepinsky and Culpepper [6,7]. The authors indicated that single-country research emphasized description, theory generation, hypothesis testing, and research design and confirmed that the single-country study can provide new theoretic insights based on the outlook of the country investigated, as well as being a viable means of answering intellectual questions. Generally, extant studies used mathematic modeling for early dynamics of transmission and control of COVID-19 [8]; evaluation and treatment of COVID-19 [9]; combination of systematic review and meta-analysis on clinical, laboratory, and imaging features of COVID-19, nationwide analysis [10]; combination of bibliometric analysis and knowledge mapping on the current status of global research on COVID-19 [11]; analysis of International Health Regulations annual report on health security capacities related to COVID-19 [12]; combination of data mining and content analysis of social media on the early outbreak of COVID-19 [1]; retweeting on consensus building, information sharing, dissent, and lockdown life regarding COVID-19 [13]; and topic modeling to understand the research hotspots that surround COVID-19 [14]. These studies share new knowledge and enlighten the public on the state of COVID-19 globally, but there is a vacuum in having a deeper understanding of the emerging themes in America concerning COVID-19. This research embarked on thematic and sentiment analysis to contribute to the ongoing academic discussion on COVID-19 in the context of America and to answer the following research questions: (1) what are the emerging themes from COVID-19 based on general opinions in/on America? (2) How do these emerging themes relate together and what insight can be generated? (3) Why do COVID-19 opinion matters, and how do these opinions connect America with other countries?

The next section of this study gives an overview of COVID-19/SARS-CoV-2 and then applies the sociotechnical theory as a lens to provide an outlook of COVID-19 with respect to the United States. The subsequent section explains the methodology and data analysis techniques employed and showcases the results in the following section. The subsequent sections discuss the results, theoretic and management implications of the study, followed by research limitations and future studies and recommendation. The final section concludes the study.

## 2. Sociotechnical theory

In the beginning of the 19th century, research on work was concentrated on the habituation of individuals to the technical and organizational setting of production [15,16].

The first discoveries reported that the rise of industrialization in coal ores had considerably slowed down the performance of the workers instead of increasing it as expected [17]. To answer this question, studies revealed that the birth of other industrialization systems brought out both technical and social constraints inseparable [18]. Concretely, it was a question of federating the efforts not only in the direction of industrialization but rather a mixture of social and technical perceptions, which are therefore the only guarantee of an important success of work planning. Later, the sociotechnical theory was developed and improved as a basis, but with ecological ramifications, in order to be able to compensate for the risks generated by the social and technical aspects [19]. The sociotechnical theory is open to the outside world, and the existing demarcation between the system and the outside world must be regulated for a clear identification of contingencies and the free flow of information [20]. The sociotechnical theory positions itself for organizations as a social entity instead of a mechanical and automated vision [21]. Technical objectives therefore depend greatly on the social environment. The sociotechnical approach gave birth to a model entitled "sociotechnical change impact model" providing a holy environment to assess the causal links within a group of individuals and thus appreciate the variations due to determining components such as individuals, tasks organization, and technology [22].

The sociotechnical opinion aspires for technology to be intrinsically indifferent and that the failures of several computer systems are due to the fact of legitimizing the importance of the associated social system since the conception [23]. Over the years, the information systems field continues to evolve and a considerable modification of the technical approach is not the only factor being considered but social specificities are also employed in understanding any given sociotechnical system [24]. Even if the new approaches tend not to dissociate the subsystems from the sociotechnical theory, it can be argued that the restructuring of an ideology of work with respect to a group of individuals must consider the consequences of each subsystem on those individuals. Also, the level of requirement and satisfaction of each subsystem should be considered. The technical subsystem is an integral part of the theory, and it is made up of the adequate methods for transforming inputs into outputs. Regarding the social subsystem, it deals with characteristics such as behaviors, attributes, and values [25]. The theory is also interested in relationships between individuals, the architecture of recognition, and the structures of authorities. The description of the nomenclature of interdependent variables in a technology-work, mission, organization, and individual set is thus highlighted in Fig. 5.1 as explained in Bostrom and Heinen's work [23]. Thus the sociotechnical theory postulates that one cannot dissociate the technical and social subsystems of any given system [23].

The establishment of a sociotechnical system implies that a group of people forming an organization is an arrangement of technical and social components coexisting with the outside world [26]. The industrial ecosystem must produce not only technical/physical elements but also sociopsychologic outputs regarding the fact that any element, either social or technical, must work together [27]. Joint optimization will therefore be

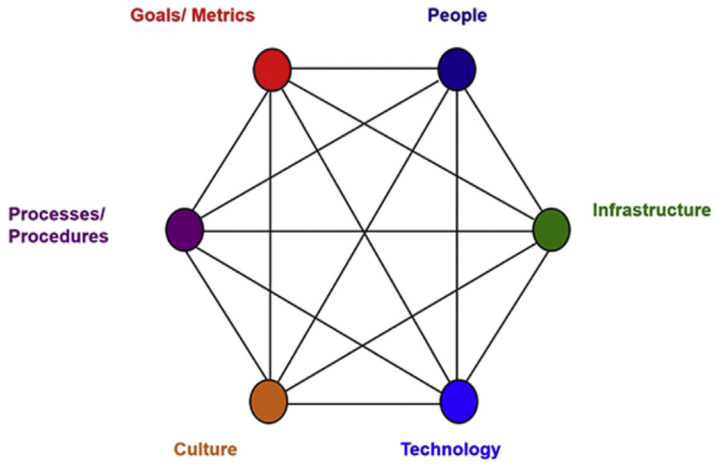



**FIGURE 5.1** Sociotechnical theory interaction [23].

achieved when both parties (social and technical) produce positive outputs from the conception of the work. Joint optimization differs from traditional methods where technical design is done first upstream and thus forcing individuals to adapt to it [28]. These traditional methods are renowned for their poor results and an extremely high mobilization of financial resources [29,30]. It has largely been dubbed as an effective methodology for modeling organizational work, evaluating computer systems, measuring the degree of satisfaction of an information system, and disseminating information technologies and communication [31]. The outlets of the sociotechnical approach are also widened to the elaboration of recommendations useful for the construction of a flexible working environment able to accept any technology. The modification of a work process by an individual where a group of individuals inevitably leads to a change in the social and technical approach until a global solution is reached. Social and technical changes are therefore prioritized and optimized jointly [24]. Particularly, it is no longer a question of being concerned with the technologies that transform organizations and individuals in the performance of their various tasks, but a question of looking at social and organizational variations in this space rich in technology.

Sociotechnical theory has been widely used in previous studies in information systems. Kim et al. [32] discovered that culture, society, and technology are an integral part of the ecosystem that builds information and communication technology. In addition, Yu et al. [33] used the sociotechnical approach to study the acceptance by users of smart TV. Paul's work has also shown the importance of social media, like microblogs, which are considered here as sociotechnical information systems [34]. They are therefore sociotechnical platforms where individuals, in addition to acquiring knowledge, can obtain information from others and thus maintain interpersonal relationships with the outside world. Barnes and Böhringer [35] assessed the consequences of the technical aspects on the habits and attitudes of internet users using microblogs from the

perspective of a sociotechnical approach. Chai and Kim [36] increased the students' knowledge and information-sharing methodologies through social media in a social and technologic aspect. Likewise, for our research, we adopted the sociotechnical approach as a lens to point out the essence of technology as a channel in voicing out opinions in society, primarily during such a difficult situation as the COVID-19 pandemic. Thus when tackling issues of this gravity, governments must not neglect social discourse on the matter at stake but must carefully follow and engage with the public in order to provide a solution. In this case, Twitter is that technical subsystem and the technologic platform that must not be neglected by authorities but rather be used as a medium for policy and decision support.

# 3. Methodology

For this study, English language posts (tweets) specifically from users registered/geographically located in the United States of America were extracted from Twitter to be analyzed into detail. The United States was a suitable choice for thematically studying the COVID-19 crisis because of the sharp rise in confirmed cases and deaths. The United States was our choice of study also because of the correlation between its economic growth and the world's economy [37]. Thus America's economic state plays have vital consequences on numerous economies during periods as the COVID-19 crisis.

The most suitable knowledge extraction methodology for our study was the Natural Language Processing (NLP) technique of text mining because of the quasi-structured nature of the dataset. NLP-based algorithms and text mining have been successful in analyzing the Syrian refugee crisis on Twitter as well as gender perspectives of stroke survivors on Twitter [38,39].

## 3.1 Data collection

We considered using the "covid19" keyword as a search term by observation on the official Twitter account of the US CDC (@CDCgov), which is one of the most relevant stakeholders during such pandemics.

The Twitter data collection process was made possible through the R package known as *rtweet* using Twitter's REST (representational state transfer) and stream Application Program Interfaces (API) [40]. The *search_tweets()* function had the following parameters:

**a.** *code* = *lookup_coords("usa")*, to limit results to tweets from the United States.
**b.** *lang* = *"en"*, to limit results to tweets in the English language.

A total of 80,824 tweets were obtained for further analysis.

In order to analyze the observations obtained, it was pertinent that data pre-processing be performed. Owing to the repeated procedure of data collection—as a result of limits to Twitter's API—duplicate observations had to be checked for. Retweets

were also eliminated so as to focus on original posts. Upon performing this first stage of preprocessing, 41,038 observations were obtained, making up for 50.52% of the original dataset.

## 3.2 Data analysis

The next stage included the following standard normalization processes using the "tm" [41] package in R:

**a.** character encoding to utf-8;
**b.** converting all tweets to lowercase;
**c.** removal of nonprintable characters (e.g., \n, \t, and emojis);
**d.** removal of selected punctuations, except the hyphen (this is because upon observing Twitter trends on covid19, many users also used the hashtag covid-19 in their posts);
**e.** removal of numerals;
**f.** removal of the word Trump, as our study was taking a neutral perspective;
**g.** removal of URLs;
**h.** collapsing multiple white spaces.

The next phase involved the tokenization of observations/tweets whereby textual information is divided into individual words [42]. This was then followed by the lemmatization of tokens to reduce the variation forms so as to obtain one-word form (for example, the words run, running, and ran will be converted to run).

Our analyses adhered to Twitter's terms, conditions, and privacy policies. Thus no personal information is utilized in this study in order to fulfill the ethical requirements of data science research, i.e., in a privacy-preserving manner [43].

In order to understand the relevant themes that are of socioeconomic importance to any country during a crisis such as COVID-19, we saw it fit to back our relevant themes under the umbrella of Sustainable Livelihood indicators. The Department for International Development (DFID) developed the Sustainable Livelihoods Framework that encompasses a number of factors (social capital, human capital, financial capital, physical capital, and natural capital) that impact on livelihood strategies and outcomes and also emphasizes the many relationships between these factors [44].

### *3.2.1 Sentiment analysis*

We approached the study by analyzing sentiments in the dataset. The goal of sentiment analysis recognize and express emotions digitally as well as to automatically determine a given subject's sentiment [51,52]. Research has pointed out that due to the average performance level of lexicon-based approaches, context-specific lexicons can be used to minimize the issue of term polarity.

First of all the study employed the NRC emotion lexicon [45], a sentiment and emotional lexicon developed by the National Research Council of Canada to evaluate the general emotions expressed as per selected topics.

The second semantic lexicon utilized was the Bing lexicon, which performs binary categorization by sorting words into positive or negative positions [46]. Finally, the AFFIN semantic lexicon, which assigns a polarity score to each word, was used [47].

According to research, lexicon-based approaches may not provide high-performance results because the terms in text data may carry a different polarity than those specified in the lexicon. Hence, we consider context-based approaches in performing sentiment analysis and interpretation. The results from the sentiment analysis (both emotional and negative or positive polarity) within the context of the selected themes of great interest to COVID-19 reveal the state of citizen or resident perceptions.

### *3.2.2 Bag-of-words model (N-grams)*

The goal of the bag-of-words model is to extract features from textual documents as well as categorize objects. The bag-of-words model, also known as vector space model, where words are represented based on their multiplicity disregarding their grammar and the word order [48].

With respect to the study of the COVID-19 pandemic using our data science technique of choice, we resolved to two-grams or bigrams to thematically understand themes and topics of interest pertaining to the sustainable livelihood indicators. In previous empirical studies, bigrams have been shown to be extremely effective, as they capture more contextual meaning by considering the neighboring words of a given phrase [49] and thus a fitting application of bigrams in this study.

Fig. 5.2 illustrates the research methodology as described earlier. The next section discusses the results obtained upon following the laid down knowledge discovery trajectory.

## 4. Results

Following the research methodology, we first of all performed a general sentiment analysis in two parts. The first sentiment analysis evaluated Americans' perspectives of

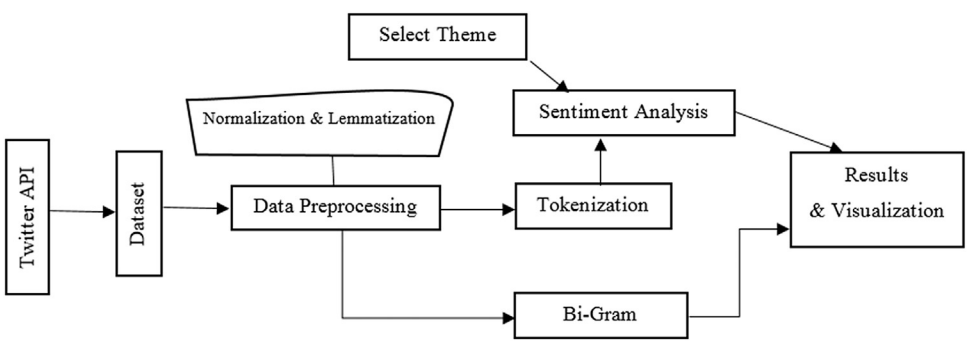



**FIGURE 5.2** Research methodology. *API*, application program interfaces.

their president during this period using the keywords President and Trump. The second assessed what Americans thought about China and Wuhan because it has been widely established as the origin of the virus.

We calculate the net sentiment as such:

$$Net\ Sentiment = Positive\text{-}Negative \tag{1}$$

From Table 5.1, per our dataset obtained from Twitter, using the NRC lexicon, it is evident that Americans expressed more negative sentiments than positive sentiments with respect to our chosen themes. Most important for this study is the possibility of measuring emotion with respect to context-specific sentiment analysis.

Table 5.2 highlights the results obtained from applying the Bing lexicon to our context-specific sentiment analysis so as to identify sentiments of Americans pertaining to the COVID-19 crisis. Evidently, a more negative outlook is observed from the net sentiment.

Figs. 5.3 and 5.4 graphically illustrate the distribution of sentiments for a sample of 30 tokens with respect to the contexts of interest using three lexicons: AFFIN, Bing, and NRC. The results are a reflection of outcomes obtained in Tables 5.1 and 5.2.

**Table 5.1** NRC emotion lexicon sentiment analysis on themes, a ("President" and "Trump") and B ("China" and "Wuhan").

| Sentiment | Score (President and Trump) | Score (China and Wuhan) |
|---|---|---|
| Anger | 1407 | 246 |
| Anticipation | 1298 | 258 |
| Disgust | 1186 | 199 |
| Fear | 2001 | 346 |
| Joy | 790 | 139 |
| Negative | 3287 | 556 |
| Positive | 2799 | 486 |
| Sadness | 1579 | 225 |
| Surprise | 728 | 114 |
| Trust | 2175 | 358 |
| **Net sentiment** | **−488** | **−70** |

**Table 5.2** Summary of Bing lexicon sentiment analyses on themes—"President and Trump" and "China and Wuhan".

| Themes | Negative | Positive | Net sentiment |
|---|---|---|---|
| President and Trump | 3029 | 1023 | −2006 |
| China and Wuhan | 468 | 164 | −304 |

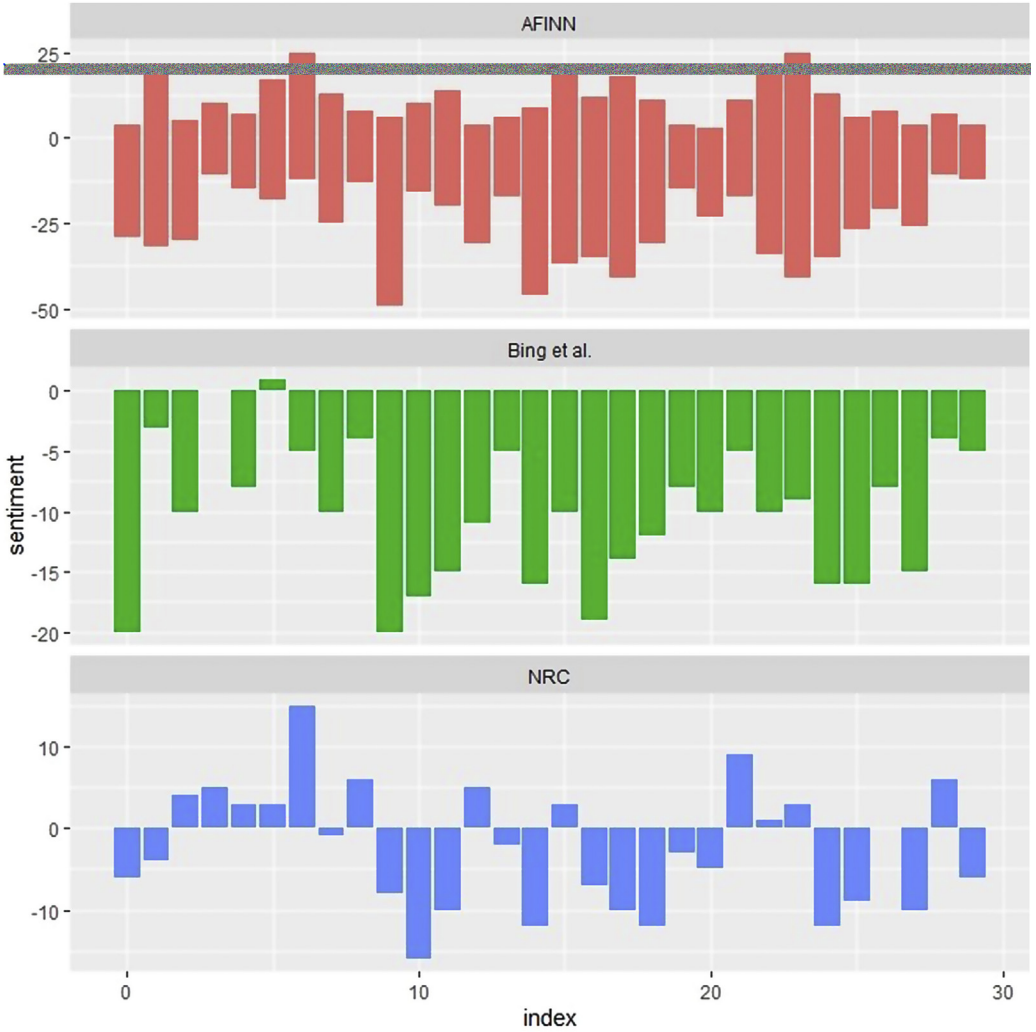



**FIGURE 5.3** Comparison of three sentiment lexicons with respect to the selected themes ("China" and "Wuhan").

For the second phase of the result description, we highlight the findings of our bag-of-words technique, precisely bigrams.

Fig. 5.5A,B illustrates the most frequent bigrams that fall under contextual themes related to the human capital index of the Sustainable Livelihood indicator. In Fig. 5.5A, concerning work and employment life, we observe frequent bigrams such as "adapt home" that reveal the level to which workers have had to adapt to working from home. Also "accept application" gives a picture of general public talk on job applications as well as unemployment appeals. In Fig. 5.5B keyword search was limited to econom*, which represents words like economy, economics, etc.; financ*, which represents terms like

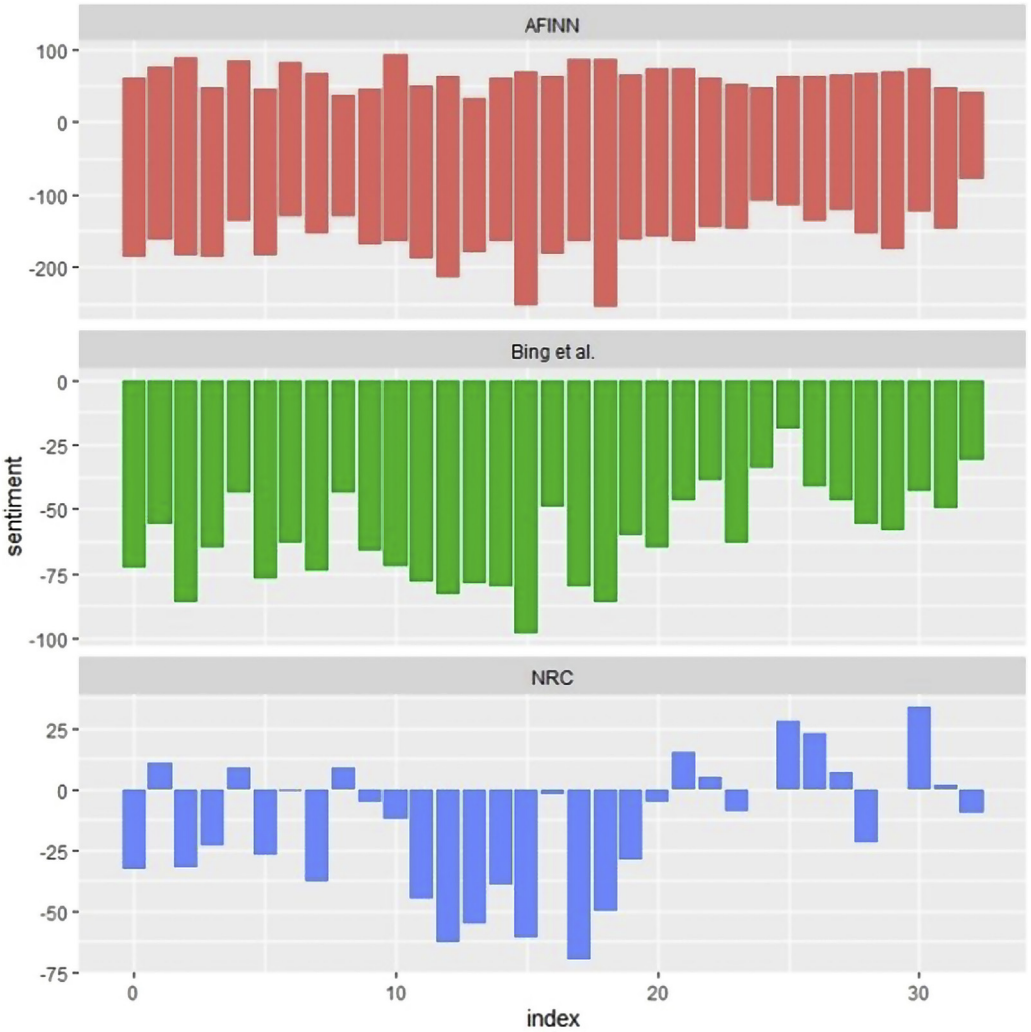
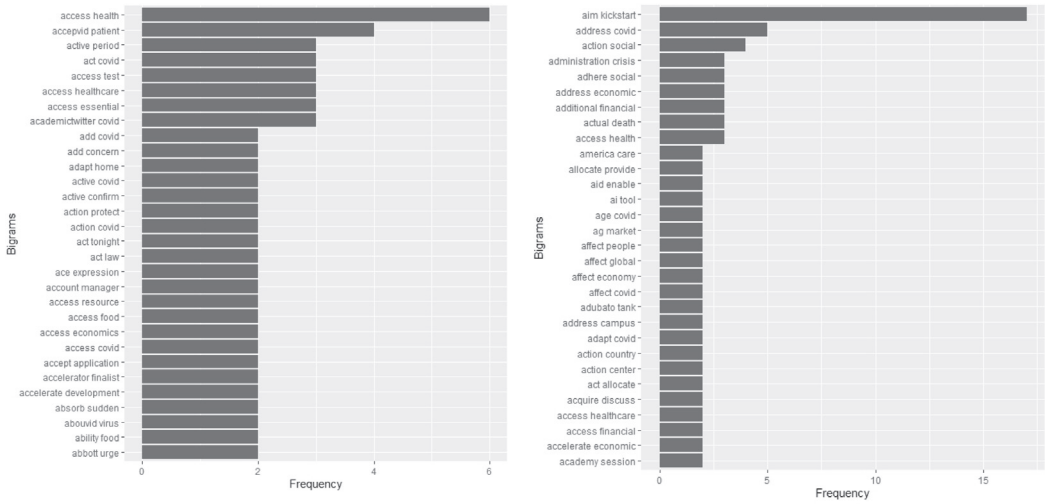



**FIGURE 5.4** Comparison of three sentiment lexicons with respect to the selected themes ("President" and "Trump").

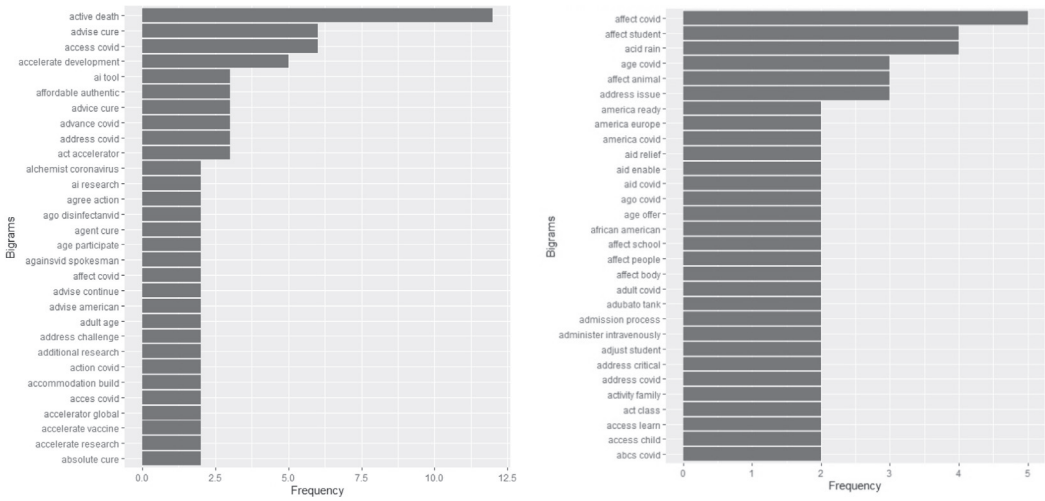
finance, financial, financier, etc.; and market in order to assess perspectives on the local and national economy. A good example can be inferred from the bigram "aim start"—upon further verification—that highlights talks around the desire of states to kick-start and reopen the economy.

In Fig. 5.6A,B, we focused on the social capital indicator by contextually selecting themes concerning the cure and vaccination for COVID-19 as well as education and schooling perspectives because schools have been shut down. From Fig. 5.6A, we observe conversations on artificial intelligence research in solving COVID-19, as well as




(a) employ, work, job, salary, income, boss (b) econom*, financ*, markert

**FIGURE 5.5** Most frequent bigrams of human capital themes: (A) employ, work, job, salary, income, boss and (B) econom*, financ*, market.




(a) vaccin*, research, cure (b) educat*, college, school, university, teach, learn, study

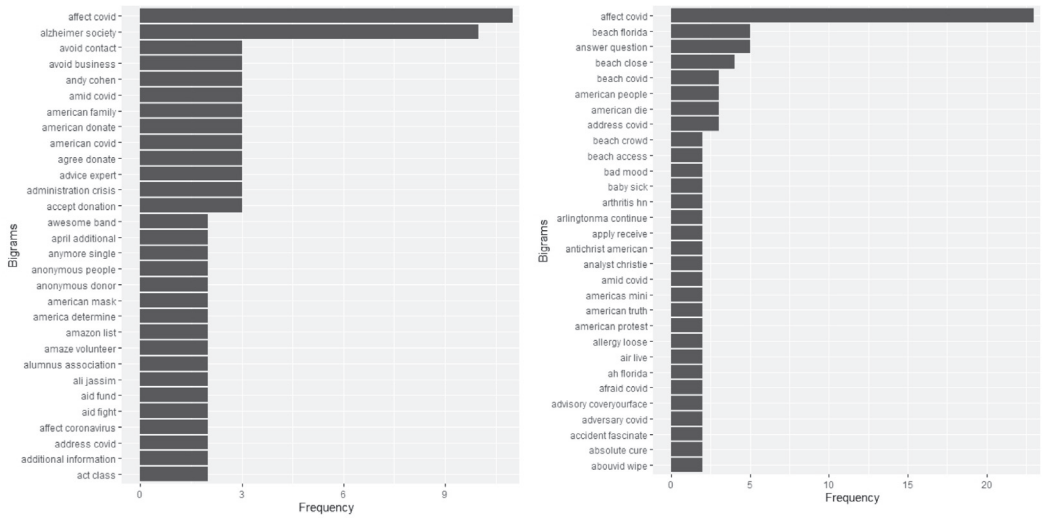
**FIGURE 5.6** Most frequent bigrams of social capital themes: (A) vaccin*, research, cure and (B) educat*, college, school, university, teach, learn, study.

accelerating research for a cure. From Fig. 5.6B, pertaining to the academic life during the pandemic, we observe the level of worry in the bigrams due to conversations using themes such as “affect school” and “access learn” and the conversations on children adjusting to schooling during the crises.

In Fig. 5.7A,B, with respect to the human capital index, the first set of keywords revealed bigrams that focused on volunteer work and donations as well as commending of volunteer efforts. The second set of keywords in Fig. 5.7B explore the outdoor American life, which revealed a majority of conversations on the closure of beaches as well as covering one’s face when outside.

Finally, Fig. 5.8A,B illustrates the findings of themes related to the physical and natural capital indices, respectively. Fig. 5.8A delves into themes connected with agriculture and conversations revealed bigrams such as chronic shortage, bird flu, agriculture critical, and the governor of New York, Andre Cuomo. Fig. 5.8B is concerned with discussions on the climate even during a crisis of this nature. The bigrams reveal conversations such as climate policy, air pollution, air quality, and many others.

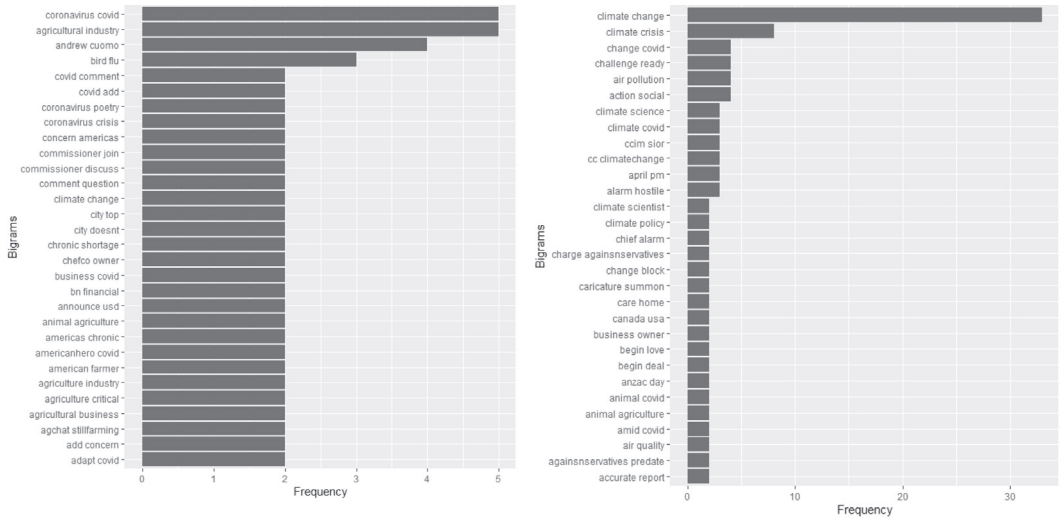
Obtaining insights from a contextual point of view using the sustainable livelihood indicator gives decision makers and the general public a fair idea of public concerns and how to act in order to preserve the sustainable ecosystem during crises of this gravity. As such, data-driven thematic approaches serve as a suitable pragmatic step.




(a) keywords: volunt*, donat*, non profit

(b) keywords: outdoor, beach, ocean, forest, creek, walk, stroll, jog

**FIGURE 5.7** Most frequent bigrams in human capital themes. Keywords: (A) volunt*, donat*, nonprofit and (B) outdoor, beach, ocean, forest, creek, walk, stroll, jog.




(a)keywords: agric, farm, crop (b) keywords: environment, climate, atmosphere

**FIGURE 5.8** Most frequent bigrams in physical and natural capital themes. Keywords: (A) agric, farm, crop and (B) environment, climate, atmosphere.

## 5. Discussions

COVID-19 lingers and upends global health and economy. Its miniature beginning cannot be compared with its escalation, and America is a hub of COVID-19. America's ingenuity and innovative response to COVID-19 scientifically, politically, financially, and communication-wise attracts the research community. Despite the great damage COVID-19 has caused the whole world, experts could only predict its mild decline in the summer. This study examines the outlook of America during the ongoing disruption of COVID-19 by employing bag-of-words model and sentiment analysis through Twitter datasets. This study revealed COVID-19-related interesting themes in America. The results show political themes between the presidency in America and Wuhan in China. COVID-19 not only kills and disrupts lives but also stems rift between political leaders, dents political images, and destroys good relationship. Another emerging theme in this study is human capital. COVID-19 shook the strong foundation of human capital in America through job losses to employees and intellectual capacity loss to employers. Besides, social capital also emerged as an interesting theme, and this study shows how COVID-19 disrupts people's networks of relationships and prevents the society to function effectively. This study established these three important themes and showed their relationships. The American government plays a central role in all the activities that revolve around COVID-19, either human or social capital issues. These results give a better understanding of the ingenuity of the American government and how it is managing the ongoing crisis of COVID-19. The study also helps us to understand the role of

the American government across borders in both positive and negative polarities. It shows the interplay of different emotional traits that COVID-19 triggers and its effects on the government decision-making. Concerning the political sentiment between the presidency in America and China and Wuhan, negative sentiments are more than positive sentiments, which is expected, but surprisingly, the trust score is higher than other sentiment scores such as anger, anticipation, disgust, fear, joy, sadness, and surprise in America and with similar experience in China and Wuhan; but these ratings are more favorable for America presidency than those for China and Wuhan.

From a sociotechnical systems theory standpoint, the sentiment analysis and text analytics techniques of data science (technology and infrastructure components) have the potential of playing a vital role in supporting the people component (governments, large corporations, venture capitalists, startups, nonprofit organizations, and researchers) in making decisions (goals/metrics component) by considering the sustainable livelihood indicators as a benchmark (culture component) so as to improve the socioeconomic livelihood (processes/procedures component) of citizens during crises of this magnitude, be it greater or lesser.

## 6. Conclusion

In this study, we sought to answer three main questions and we have been able to provide these answers. To summarize it all from an American social media perspective, using data science techniques for knowledge extraction, the emerging themes from COVID-19 focusing on the sustainable livelihood indicators include conversations on artificial intelligence as a tool in solving the crisis, adherence to social distancing regulations, climate change and climate crisis as relevant themes amid the pandemic, acid rain as a result of the spread of the virus, and kick-starting the economy in numerous states due to the lockdown situation. These themes are relevant to America's socioeconomic livelihood and affect the world's economy at large. This is in line with research that stated that "lingering uncertainty about the direction of U.S. policy could dampen activity and investment abroad" [50].

With respect to limitations of the study, due to Twitter's developer account limitation on the number of requests possible as well as obtaining posts earlier than 7 days, our dataset was limited to a small part of the COVID-19 timeline. Thus we were not able to obtain a comprehensive dataset distributed across the first 3 months of the pandemic.

For future studies, we recommend researchers to apply the context-based sentiment analysis approach we used in our study across certain periods in order to evaluate the rate of change of sentiments over time.

Future studies may also consider including the use of emojis in posts to assess whether emotional sentiments align with the textual sentiments in posts.

Finally, future studies should be expanded to other languages and countries in order to ascertain global overviews with respect to the COVID-19 pandemic.

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