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Twitter-Based Sentiment Analysis and Topic Modeling of Social Media Posts using Natural Language Processing, to Understand People's Perspectives Regarding COVID-19 Omicron Subvariants XBB.1.5 and BF.7

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Abstract

Concerns about an increase in cases during the COVID-19 pandemic have been heightened by the emergence of a new Omicron subvariant XBB.1.5 that joined the previously reported BF.7 as a source of public health concern. COVID-19 cases have been on the rise intermittently throughout the ongoing pandemic, likely because of the continuous introduction of SARS-CoV-2 subtypes. The present study analyzed the Indian citizen's perceptions of the latest covid variants XBB.1.5 and BF.7 using the natural language processing technique, especially topic modeling and sentiment analysis. The tweets posted by Indian citizens regarding this issue were analyzed and used for this study. Government authorities, policymakers, and healthcare officials will be better able to implement the necessary policy effectively to tackle the XBB 1.5 and BF.7 crises if they are aware of the people's sentiments and concerns about the crisis. A total of 8,54,312 tweets have been used for this study. Our sentiment analysis study has revealed that out of those 8,54,312 tweets, the highest number of tweets (n = 3,19,512 tweets (37.3%)) about COVID variants XBB.1.5 and BF.7 had neutral sentiments, 3,16,951 tweets (37.1%) showed positive sentiments and 2,17,849 tweets (25.4%) had negative sentiments. Fear of the future and concerns about the immunity of the vaccines are of prime concerns to tackle the ongoing pandemic.

Keywords: XBB 1.5, BF.7, Omicron Subvariants, Natural Language Processing, Sentiment Analysis, Topic Modeling, Twitter-based Analysis

INTRODUCTION

At the end of 2019, China reported the first case of coronavirus disease (COVID-19), which was brought on by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] Within a short period, this virus quickly spread to numerous other countries and, as a result, caused a devastating pandemic that affected more than 200 countries worldwide.[2] At the time of writing, more than 5 lakh people have scummed to the COVID-19 crisis in India alone.[3] The SARS-CoV-2 virus, the cause of this global epidemic since its detection in 2019, belongs to the large family of viruses known as coronaviruses.[1,4] Since new SARS-CoV-2 varieties evolve continuously with varied transmissibility, contagiousness, and mortality rates, it appears difficult to terminate the present pandemic despite ongoing vaccination programs and booster shots.[5] European Centre for Disease Prevention and Control (ECDC) routinely screens for genomic variants and evaluates novel variants based on intelligence about epidemics.[6,7] A recent study that appeared in The Lancet found that the COVID-19 vaccine saved an estimated 19.8 million lives and cut the potential global death toll from the epidemic by almost two-thirds in its first year.[8] Governments worldwide have recommended that their citizens be given two doses of vaccines for proper immunity.[9] Although the first two doses of the COVID-19 vaccine can protect people from serious COVID-19 cases and death, immunity tends to weaken over time, which raises the necessity to have booster shots to maintain the protective levels of immunity as SARS-CoV-2 mutates continuously and with the continued emergence of new variants that could elude host immunity.[10] The emerging SARS-CoV-2 variants, such as Delta, Omicron, and its lineages (variants of concern, VOCs), have been found to have significant negative effects by overriding the protective immunity brought on by COVID-19 vaccines and antibody-based therapies, leading to vaccine breakthrough infection, re-infection, and an overall rise in cases and deaths amid different waves of the ongoing pandemic.

Omicron (Pango lineage B.1.1.529) mutates at a much higher rate than any other previously circulating VOC, and it became the worldwide dominant variety after acquiring new mutations and splitting into several subvarieties, each of which has its own distinctive epidemiological, clinical, and viral signature as it spread around the world.[6,7,11-13] There are at least 50 differences between the Omicron variant and the reference strain, with roughly 27 differences found in the viral S protein that may cause RBD (receptor binding domain) motif accumulations. Omicron S protein RBD mutations that boost its affinity for the human ACE2 (angiotensin converting enzyme 2) receptor facilitate virus entry into human cells.[14]

Recently, a more contagious and highly transmissible Omicron variant, XBB.1.5, has attracted global attention due to rise in cases in the USA. This is in addition to the BF.7 subvariant of omicron, which has been in the news due to its spread in China and a few other countries, posing a worrisome situation of rise in COVID-19 cases again. Subclade BF.7 of Omicron variant BA.5 has the greatest infection potential due to its rapid transmission and short incubation period; it can also reinfect or infect the immune system of previously infected individuals.[15] Notably, the highly contagious Omicron strain, specifically BF.7, which originated in Beijing and is now spreading throughout the rest of the country, has caused a COVID outbreak in China after a lengthy period since the first lethal disease outbreak began as a pandemic in early 2020.[16] Poor immunity from previous SARS-CoV infections and possibly less vaccination could be to blame for the BF.7's high transmissibility in China. It has also been discovered in the United States, the United Kingdom, Belgium, Germany, France, China, and Denmark.[17] Global health officials are worried about the rapid spread of the XBB.1.5 Omicron subvariant in the northeastern United States. Up until recently, this variant was the most widely spread. Although the World Health Organization (WHO) has yet to collect data on XBB.1.5's severity, there is currently no evidence to imply that it is more harmful than earlier subvariants. This is because alterations in this omicron subvariant improve the virus's ability to adhere to cells and replicate within them.[7,18] WHO has not compiled data on the severity of XBB.1.5 yet, but there is no reason to believe that it is more harmful than previous Omicron strains. Science has revealed that XBB.1.5, like its close relatives XBB and XBB.1, can evade the immune responses triggered by immunizations and diseases. However, XBB.1.5 has a mutation that gives it an edge in connecting to cells, which in turn boosts its development.[19] Viruses that can infect humans who have already been exposed to them, either by infection or immunization, are said to exhibit immunological evasiveness. The RBD of XBB.1.5 contains a mutation with the unusual name "F486P," which allowed it to accomplish this feat. It is unclear whether or not this phenomenon is a contributor to mental illness. Experts have assessed this to be extremely unlikely.[6,20]

Presently, Omicron subvariants XBB.1.5 and BF.7 are rapidly spreading in the United States, Europe, and China is the most virulent SARS-CoV-2 strain to date, according to the World Health Organization (WHO).[21] The immune evasive nature of the XBB 1.5 and BF.7 subvariants will increase hospitalizations and deaths as more people overall

Graphical Representation of Table 1 (By Number of Tweets)

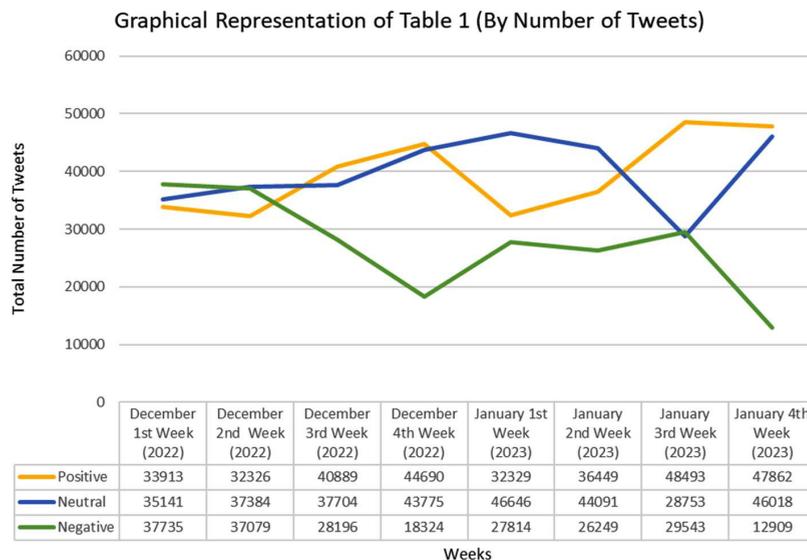|	December 1st Week (2022)	December 2nd Week (2022)	December 3rd Week (2022)	December 4th Week (2022)	January 1st Week (2023)	January 2nd Week (2023)	January 3rd Week (2023)	January 4th Week (2023)
Positive	33913	32326	40889	44690	32329	36449	48493	47862
Neutral	35141	37384	37704	43775	46646	44091	28753	46018
Negative	37735	37079	28196	18324	27814	26249	29543	12909

Figure 1. Representation of Sentiment Analysis results by number of tweets

are infected and reinfected.[22] Additional spike mutations, enhanced transmissibility, and immune evasion features in these Omicron subvariants have been linked to their ability to circumvent the protective effects of COVID-19 neutralizing antibodies, vaccinations, boosters, and therapies.[23]

Research Methodology

Due to the widespread availability of the internet and the widespread usage of social media platforms, individuals now have the ability to freely express and disseminate their opinions and concerns on any matter. Ever since the emergence of COVID-19 crisis, many studies were conducted analyzing the social media data to understand the perception of general public regarding the crisis.[24-27] People have been utilizing social media platforms to communicate their emotions regarding the emergence of the new COVID variants XBB.1.5 and BF.7. In this study, we aimed

Table 1. Sentiment Analysis

Week	Total Tweets	Positive	Positive %	Neutral	Neutral %	Negative	Negative %
December 1st Week (2022)	106789	33913	10.7	35141	10.9	37735	17.32
December 2nd Week (2022)	106789	32326	10.1	37384	11.7	37079	17.02
December 3rd Week (2022)	106789	40889	12.9	37704	11.8	28196	12.9
December 4th Week (2022)	106789	44690	14	43775	13.7	18324	8.4
January 1st Week (2023)	106789	32329	10.1	46646	14.5	27814	12.7
January 2nd Week (2023)	106789	36449	11.49	44091	13.7	26249	12.04
January 3rd Week (2023)	106789	48493	15.29	28753	8.9	29543	13.5
January 4th Week (2023)	106789	47862	15.1	46018	14.4	12909	5.9

Table 2. Topic modeling results

Topic Label	Top Words
Fear of future	Covid, doubt, future, high, fear, time
Immunity of the vaccines	Vaccine, risk, case, immune, save, could
Pace of spreading	Fast, spread, going, bad, going, all
Government's incompetence	Policy, government, fail, destruct, serious, taken
Wondering herd immunity	Immunity, worse, save, herd, can't, do
Deadliness of the virus	Deadly, variant, serious, much, omicron, severe
Fear of education	Education, affect, kids, school, shut, worse
Lockdown	Fear, livelihood, lockdown, suppress, bad, money
Blaming China	Covid, variant, ill, reason, China, produce
Transportation	Lockdown, bus, going, travel, restrict, stress

to gain insight into the opinions and concerns expressed by Indian citizens on social media regarding the high transmissible COVID variants XBB.1.5 and BF.7 through an analysis of the social media posts of the Indians. According to recent studies, studying data from social media is one of the most reliable ways to forecast, manage, and avert a health crisis or pandemic.[28] It is also crucial for government officials and policymakers to have a comprehensive understanding of the public's perspectives regarding any health policies that are under consideration, as this knowledge will facilitate the attainment of the desired outcomes from such policies.[29-31]

Twitter has developed into a platform where individuals may share their stories, feelings, and opinions about health issues since the start of the COVID-19 epidemic. As a result, we decided to use tweets as our study's data source. Numerous studies were carried out utilizing data from Twitter during the early stages of COVID-19 to study the situation and comprehend how the general public saw health policies and different pandemic-related issues.[32-34] When the scientific

community assumed that the worst was over, new variations surfaced, causing chaos in several countries, including India. Government authorities and policymakers must comprehend the opinions and views of the general public regarding the two highly transmissible COVID variants, XBB.1.5 and BF.7,[35] in order to successfully execute a policy and promote proper disease prevention methods and public safety precautions. In order to understand how the Indian general population's opinion about these two versions, we applied natural language processing (NLP) techniques, particularly sentiment analysis and topic modeling.

Data Collection
Using the Python library Twint, tweets from Indian users between December 2022 and January 2023 that contained the keywords "XBB.1.5" and "BF.7" were scraped. The data we get from social media is unstructured, so we need to pre-process the data. After removing duplicates and tweets from other languages, we used 8,54,312 English tweets posted by Indians for this study.

Data Cleaning
Data cleaning is crucial to get the desired outcome from text analytics research.

Before beginning our research, we cleaned the data, which entailed deleting all the items that were not required for textual data analysis. Stop words, punctuation, URLs, and other undesirable elements that were not required for text analytics were removed. Stop words include letters like "a, "an," and "the," which have no inherent meaning and are hence unnecessary for analysis. Additionally, we lemmatized and stemmed the data in our corpus.

Lemmatization, is the act of organizing a word's inflected forms according to the lemma of the term.[36] By restoring the word to its dictionary form via vocabulary analysis, this technique eliminates word inflectional ends. The same objective is being pursued by stemming as well but using a different method. Lemmatizing uses more informed analysis to cluster words with similar meaning contextually around the word, the part of speech, and other criteria, in contrast to stemming, which arbitrarily chops off the ending of the words using heuristics without taking the context in which the word appears.[37]

Sentiment Analysis
Sentiment analysis is an algorithmic technique for gathering and examining subjective evaluations of various characteristics of a thing
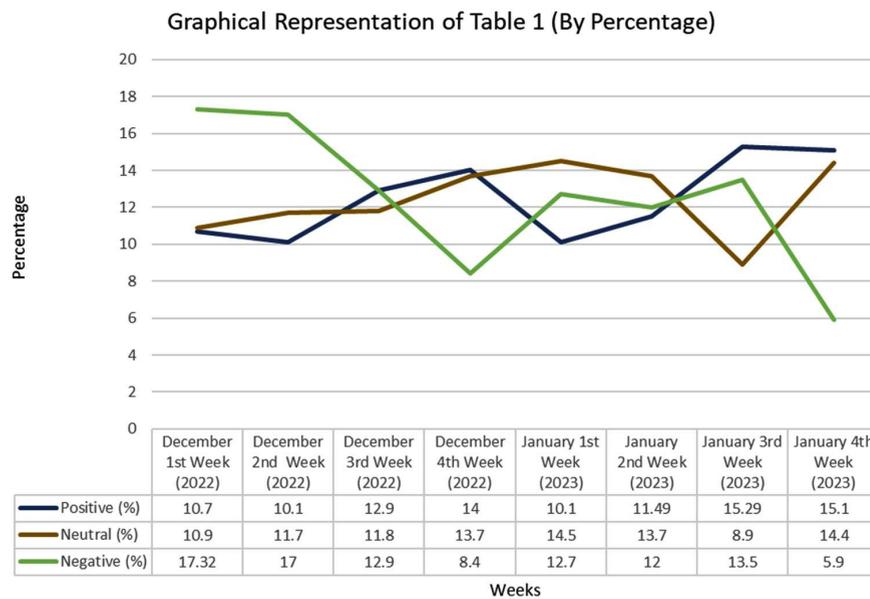

Figure 2. Representation of Sentiment Analysis results by the percentage

Graphical Representation of Table 1 (By Percentage)

	December 1st Week (2022)	December 2nd Week (2022)	December 3rd Week (2022)	December 4th Week (2022)	January 1st Week (2023)	January 2nd Week (2023)	January 3rd Week (2023)	January 4th Week (2023)
Positive (%)	10.7	10.1	12.9	14	10.1	11.49	15.29	15.1
Neutral (%)	10.9	11.7	11.8	13.7	14.5	13.7	8.9	14.4
Negative (%)	17.32	17	12.9	8.4	12.7	12	13.5	5.9

or entity. Sentiment analysis enables us to comprehend the text's underlying assumptions and the author's emotions.[38] Assessing the opinions of the general public on a certain issue, such as a specific health policy, may assist policymakers and governments in determining what concerns are being shared by the general public regarding the crisis and the necessary health policies that can be adopted. We employed sentiment analysis in our work to comprehend how Indian social media users felt about the COVID variants XBB.1.5 and BF.7. and the major concerns they shared about the crisis. The Python module TextBlob was utilized for the sentiment analysis procedure. The TextBlob library analyzes every word in the paper included in the corpus using powerful machine learning methods and natural language processing, categorizing the overall sentiments as positive, negative, or neutral. The bag-of-words paradigm and a specified vocabulary for categorizing negative and positive terms are the foundations of the TextBlob library. Each word in the text is given a score individually using the TextBlob library, and the overall score of the document is calculated via a pooling operation (averaging all feelings).[39] Textblob provides each document's compound (polarity) score. Textblob will ultimately assign a composite score to each document in the corpus. The range of the compound score is from -1 to +1. Any document with a compound score of less than -0.5 is considered negative. The neutral range is -0.5 to 0.5. Positive is defined as +0.5 or above.

RESULTS

This study was conducted in two halves. First, sentiment analysis was performed to understand people's sentiments towards COVID variants XBB.1.5 and BF.7. Sentiment analysis detects the sentiments expressed by a person in a text. TextBlob algorithms examine each word in the tweet and determine whether the general sentiment of the particular text in the corpus is positive, negative, or neutral.[40] Second, LDA topic modeling was utilized to identify the major aspects that Indian social media users discussed regarding the COVID variants XBB.1.5 and BF.7 on social media. Topic Modeling is an assemblage of algorithms that summarizes a massive corpus of texts by independently identifying obscure

subjects and themes covered by a collection of corpora. LDA adheres to the Bayesian principle, where the algorithm considers that each text in the corpus is composed of a variety of discrete topics, each of which has a multinomial word-frequency distribution.[41,42] A total of 8,54,312 tweets were used in this study. We selected an equal number of tweets every week in the corpus for an effective comparison. The sentiment analysis study revealed that out of 8,54,312 tweets, the highest number of tweets (n = 3,19,512 tweets (37.3%)) about COVID variants XBB.1.5 and BF.7 had neutral sentiments, 3,16,951 tweets (37.1%) showed positive sentiments and 2,17,849 tweets (25.4%) had negative sentiments. The results of the sentiment analysis was as shown in Table 1. The graphical representation of the Table 1 was shown in the Figure 1 and Figure 2.

The results of the topic modeling are given in Table 2. Since the main focus of our study is to understand the concerns being shared by the Indian public regarding the new emerging variants, we only used tweets with negative sentiments for our study. Our analysis shows that the fear of what may happen in the future, fear of if the vaccines are immune enough to prevent the crisis, worry about the pace of the spreading of the virus, the incompetence of the government in handling the crisis, whether the herd immunity will prevail, wondering about the deadliness of the virus, fear if the education of students may again get affected, worrying about the lockdown, China being responsible once again and transportation are the major aspects being featured more in the tweets having negative sentiments.

DISCUSSION

We conducted our study in two parts. In part 1, we used sentiment analysis to understand the perception of Indians regarding the current BF7 and XBB1.5 crisis. In the second part, we used social media posts about the crisis that have negative sentiments to understand the concerns of Indians regarding the crisis. Our sentiment analysis results show that social media posts of Indians about the crisis in positive and neutral sentiments nearer to each other. Further, we found that 25.4% of the social media posts about the crisis are in a negative tone. Approximately one in

four Indians are more likely to post a social media post about the crisis in a negative tone. Further, we tried to analyze if there is any correlation between the perception of Indians regarding the crisis and the timeline of the crisis. For the study, we have analyzed the first eight weeks of the crisis (December 2022 to January 2023), and we found one sharp observation that compared to the first and the second week of the crisis, the last two weeks of January 2023 shows a steep decrease in the percentage of negative sentiments and an increase in the positive sentiments. The neutral sentiments. With a whopping 75% of the Indian population on social media having either posted positive or neutral sentiments about the crisis, it can be assumed that Indian citizens are not yet panicked to that extent by the crisis. However, if the crisis intensifies in the future, this lackluster attitude may result in destruction.

It is important to remember the recent uptick in COVID-19 cases in China, the United States, and elsewhere, and to continue using effective infection prevention and control measures until this epidemic ends. There is a lot more to learn about Omicron and its various subvariants and lineages.[6,7] The transmission of Omicron subvariants and lineages, the efficacy of vaccines, immunotherapeutics, and antiviral drugs against them, and the enhancement of surveillance and monitoring, as well as the strengthening of genomic facilities for tracking their spread, tight vigilance, and shedding more light on their evolution and mutational events, would all benefit from further exploration and investigation to aid in the development of appropriate mitigation strategies.[19,43] As a result, if the number of COVID-19 cases were to increase again, especially among the most susceptible members of society, as well as in the event of a vaccination breakout or reinfection, the likelihood of significant illness and hospitalization would rise.[44] Furthermore, reducing the occurrence of mutations and recombination in the virus can be aided by bolstering a single health approach and emphasizing its significance in combating zoonosis and reversal zoonosis connected with COVID-19. This applies to both domesticated and wild animals.

Our topic modeling results show that most of the negative sentiments posted by Indians were linked with the suffering caused by the first two waves of COVID-19, like lockdowns, transportation, the shutdown of schools, and the fear of the government's incompetence. Considerable Indians also shared concerns about the spreading pace of the virus and the deadliness of the virus. There was also a negative opinion about the herd immunity concept. There were some general concerns about the future and a conspiracy theory that linked China with the crisis. It is important for government officials, medical officials, and policymakers to understand the major concerns of the Indian population about the crisis and the necessary policies that should be adopted. Medical officials, on their part, should conduct a detailed research about the immunity of the vaccines and whether they can protect against the ongoing crisis and publish the results to clarify the Indian population. On the other hand, the government should announce policies considering the fear of lockdown and the fear of shutdown of schools and announce necessary policies to counter the crisis if it becomes intense in the future.

In order to forestall the spread of a potentially devastating new wave of COVID-19, we must now take the necessary precautions and use the suggested preventative and control measures. In addition to increasing immunization rates and vaccination coverages, reducing vaccine hesitancy and overcoming resistance to promoting booster shots, ensuring universal access to vaccines on a global scale, and generating sufficient herd immunity, COVID-19-appropriate behaviors and safety measures, such as the use of face masks, regular hand washing, and norms of social/physical distancing, hygiene and disinfection practices, and the avoidance of crowded places and mass gathering events, may prevent the In the long run, this will aid in preventing the spread of COVID-19 and the deaths it causes, and it will also help in the fight against the emergence of new Omicron subvariants.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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None.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

Not applicable.

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