A Sentiment Analysis of Persian Twitter over a Five-Year Period; From the Medical Error in the Death of a Celebrated Iranian Filmmaker to COVID-19

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ABSTRACT

In recent years, the field of medicine in Iran has faced significant public scrutiny, influenced by two major health crises: the 2016 death of acclaimed filmmaker Abbas Kiarostami due to a medical error and the COVID-19 pandemic. This study examines shifts in the emotional and discursive climate surrounding medicine and physicians on Persian Twitter before and after these events. Using relevant medical hashtags, over 131,000 tweets from 2015 to 2020 were analyzed through sentiment analysis, employing a rule-based approach with NVivo12 software.

The findings reveal a sevenfold increase in tweets about medicine during Kiarostami's death, accompanied by heightened negativity and associations of terms like "error," "negligence," and "mistake" with medicine which has resulted in the reconstruction of 'medical error.' Additionally, as a result of the association of the terms' error,' 'negligence,' and 'mistake' with 'medicine,' the obviousness of the physician's holiness and respect for medicine has deteriorated, and the association of the terms' value and credibility' with medicine has been de-naturalized. However, during the COVID-19 pandemic, the sentiment shifted positively, reflecting greater appreciation for the medical profession.

This study highlights how public sentiment towards medicine changes in response to major health crises, emphasizing the interplay between public sphere and trust in healthcare systems. Understanding these dynamics can inform strategies to rebuild trust and address public concerns about medical practices.

Keywords— Twitter, Iran, Physician, Medical error, COVID-19, Abbas Kiarostami.

1. Introduction

Recent years have been contentious among Iran's medical and physician communities. The high income of physicians [1–3] forcing patients to pay for unconventional costs [4, 5], the vertical relationship between physician and patient [6], and their irresponsibility in the field of medical error [7–9] are just some of the issues that have brought the medical sphere and physicians under the Iranian public's microscope and increased public opinion's judgment of them. Nonetheless, the death of Kiarostami, a renowned Iranian filmmaker, as a result of what was reported to be a medical error, as well as the pandemic of COVID-19 and the medical staff's actions in the name of public health, are two health crisis events that, according to the data obtained (Figure 1), have garnered considerable public attention and sparked additional discussions in the medical community. Issues in this area have attracted considerable attention, particularly on Twitter. This is demonstrated by our data from the time series of Persian language tweets and peaks that we created and examining the most popular topics within each peak (Figure 1).

Socialization in health issues

Today, doctors and patients frequently use online networking sites to exchange information and experiences regarding healthcare issues. Through the digital world, internet users generate information about health care and use social media to create their own reviews and ratings [10]. Patients, in particular, create thousands of pieces of content each day on social media to evaluate their doctors' performance [10]. For example, one study discovered that patients and their families react differently to medical errors on social media, expressing frustration, anger, or humor [11].

With the growing use of social media to exchange views on critical and everyday health issues in recent years, numerous studies have collected patient-reported health information using these platforms [12, 13]. In recent years, these web-based opinions have become a valuable resource for mining user sentiments [14]. These data enable policymakers to assess the healthcare system's poor quality [15]. Twitter is also an effective tool for gauging public sentiment toward a particular event. Chew and Eysenbach (2010) examined Twitter to determine the public perception of H1N1 that was trending [16]. Another study examined the Twitter conversation surrounding the 2015 Zika outbreak [17]. They discovered that increases in tweeting activity typically occurred in response to significant disease-related events. Sentiment analysis of English tweets reveals global emotional trends during the pandemic. The findings indicate that negative emotions predominated during the COVID-19 pandemic and that public emotions shifted from fear to anger [18].

The information provided above and the type of studies described demonstrate that social media - particularly Twitter - is usable and sufficient for research in critical and even everyday health situations. By utilizing this level of health information sharing, it is possible to gain a better understanding of the general public's perceptions toward physicians and medicine by analyzing social media data.

According to the cases cited, studying social media, particularly Twitter, and its conversations can provide insight into the public's feelings and attitudes toward medicine and physicians when discussing health events. The extent to which these events can alter public sentiment and perceptions about the field is a complex and time-sensitive issue that has become more comprehensive and rapid with the advent of social media and the proliferation of user-generated social data.

According to research by Yeung et al. (2021), health-related research on Twitter is highly diverse, with topics such as professional education in healthcare, big data and sentiment analysis, social marketing and substance use, young adults' physical and emotional well-being, and public health and health communication among the most frequently discussed [19]. While big data analysis and sentiment analysis for health-related issues have been major topics in recent years, a closer look reveals that most research in this area is focused on improving the mechanism by which top physicians identify or effective drugs. Additionally, the following stages investigated disease outbreak prediction, fake news, misinformation, and the relationship between physician and patient.

As previously stated, studies that assess patients' and users' perceptions and experiences with the health system [20, 21], physicians [22, 23], disease [24], or prescription drug quality [20] using big data analysis and sentiment analysis methods have a relatively high number of participants. However, most of these studies examined public perceptions of physicians at the micro-level (e.g., users' opinions of a particular physician, hospital, or drug) focusing on a case study, without creating a broad vision. In contrast, those that examined public perceptions of physicians at the macro-level (e.g., public perceptions of medicine and physicians in general, or traditional or modern medicine) discovered less.

A few studies have looked at this question at a macro level, including the Kim et al. (2020) study, which examined public perceptions of medical error in Australia using a survey method [25], the Desbiens et al. (2005) study, which assessed public perceptions of alcohol consumption by physicians on duty using a telephone survey [26], and the Fadlallah et al. (2016) study, which examined knowledge, beliefs, and attitudes of patients and the general public towards interactions between physicians and patients through a systematic review [27].

Few studies have examined medical issues from a social science perspective in the field of Persian research. For example, Ekhlasi (2016) examined the role of medical ethics in treatment relationships [28], while Fazeli et al. (2019) examined music therapy in social media [29]. Additionally, in the field of medical error, Javaheri (2014) examined the sociological demand for medical error transparency in Iran [30], and Heydari et al. (2016) examined people's opinions on how to express medical error via phone interviews[9]. It should be noted that one of the outcomes of Persian studies on medical research is the consideration of patients' respect for physicians and the hegemony of physicians' power in this space [31–33], which is relevant to the subject of the current study.
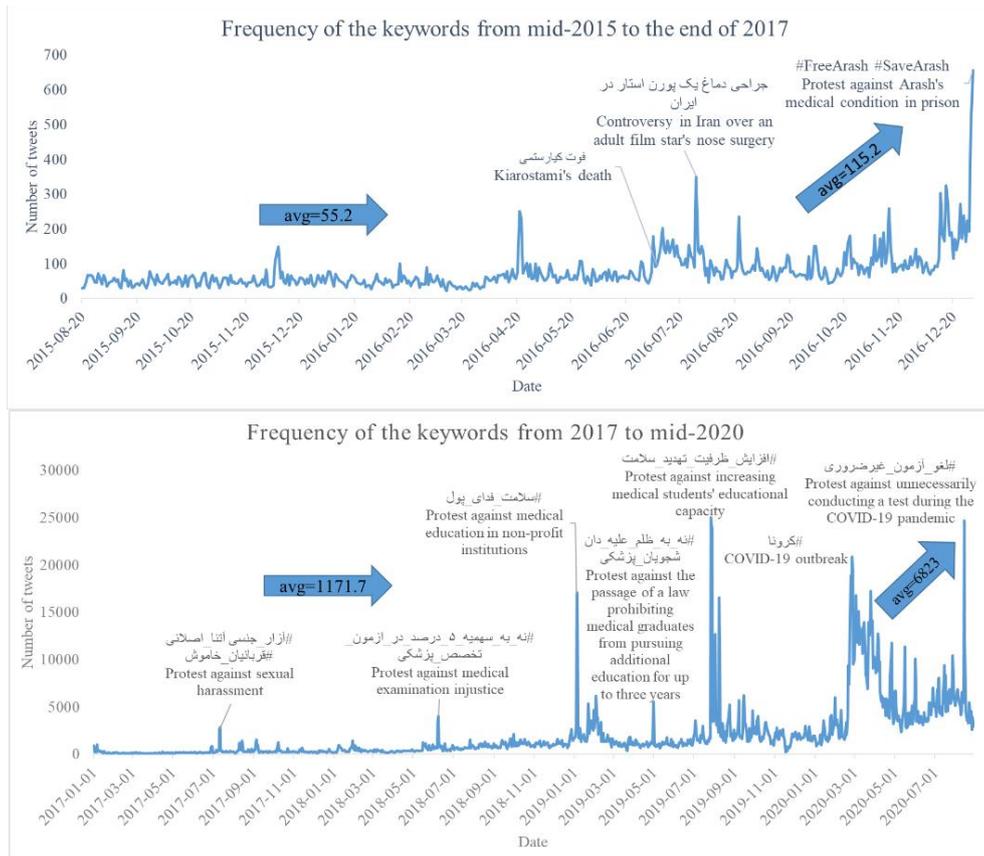
Figure. 1.   The frequency with which the keywords have been used in the last five years

After reviewing the relevant literature, we discovered that no research has examined public perceptions toward medicine and physicians at the macro level and using big data and sentiment analysis methods. Thus, a review of the available literature reveals two significant gaps in the literature. According to our examination, the first gap in research has been a lack of attention paid to the perceptions and feelings of Persian-speaking people toward the medical community. The second gap is that no longitudinal studies have been conducted, mainly using new Big Data tools, to examine the impact of health crises on the general perception and emotional atmosphere of Persian-speaking Twitter users. This is doubly true in light of the last five years' two significant events (medical error during the death of Abbas Kiarostami in 2016 and the outbreak of COVID-19 virus disease- as the most crucial health crisis of the century).

2. Medical and Plutchik's Wheel of Emotions

Observing these trends motivated this study to investigate these two events (identified using data from Persian Twitter accounts) to ascertain, using sentiment analysis techniques, the sensory and content space of public perceptions of the field of physician and medicine before, during, and after these events. According to the data gathered, two health crisis events drew widespread public attention and sparked more discussion toward physicians and medical professionals than at any previous time in history.

In addition to extracting the negative and positive sentiments used often in sentiment analysis studies [34], we considered the emotion of trust when analyzing the sentiments of these two crises affecting the field of medicine and physicians. According to Plutchik's Wheel of Emotions [35], trust is one of the eight fundamental emotions, and given the subject of this study and the issue of physician credibility and trust, it is critical to determine the extent to which it has changed over time. These words and words with related concepts were studied in the set of words with 'value and place of conflict' to extract the concept of trust from data. The term' place of conflict' is used in the title because of the importance of the concept and the difficulty in assigning it to identities.

It should be noted that psychologist Robert Plutchik developed the Plutchik Model. There are eight basic emotions, as indicated by the model: joy, trust, fear, surprise, sadness, anticipation, anger, and disgust [35]. Plutchik's wheel of emotions classifies

these eight basic emotions according to their physiological function [36].

Not limited to the analysis of general emotions such as positive and negative, as well as the use of trust as a fundamental human emotion, this research is based on the fact that, while numerous studies have examined general sentiment valences and discourse topics, specific emotions are more closely associated with psychological processes and behaviors than the overall positive and negative valences [18].

We addressed the following research questions in light of the preceding topics:

RQ1: How has the volume of negative, positive, and value signs changed after Abbas Kiarostami's death and the COVID-19 epidemic?

RQ2: What conceptual context is each period's presentation of positive, negative, and valuable signs?

RQ3: Given the two health crises in recent years, have we seen a shift in the public's perception toward medicine and physicians on Persian Twitter?

3. Study Context

For many years, the public has had high regard for the medical profession and physicians. Even before modern medicine became a new discourse in Iranian society, 'Hakim' was widely respected as an accomplished therapist practicing traditional Iranian medicine [37]. However, despite society's continued respect for this profession and its practitioners, recent years have been contentious for the field of medicine in Iran, according to various events. This field has been placed under the magnifying glass of Iranian public opinion, increasing the judgment about them.

A tragic death and a pandemic

The 2016 death of Abbas Kiarostami, a well-known Iranian filmmaker, sparked a massive debate on social media, particularly Twitter, about medical malpractice in Iran. Kiarostami's family stated that they were unaware of his illness's severity until shortly before he died in Paris [38]. Soon after his tragic death, Iranian users expressed their feelings and experiences about Iran's health system and, in particular, medical malpractice, using hashtags such as 'Health System Reform,' 'Patient Rights,' and 'Medical Failure' [39].

The COVID-19 outbreak is another medical crisis that has affected Iranian society. On December 31, 2019, the Chinese government warned about an unknown virus spreading throughout the country [40]. Within a short time, the disease spread rapidly throughout China and other countries worldwide. The hashtags 'کرونا' (#Corona) and 'ویروس کرونا' (#Corona virus), among others, quickly gained popularity in Persian Twitter, and users discussed a variety of topics, including the primary cause of the virus outbreak, governmental decisions, and mental illness caused by lockdowns [41].

Understanding peripheral and influential phenomena in research

The diagrams of our keywords were extracted in the last five years (Figure 1), and the relative extremes of each period were identified to examine the possible variables that could affect the research objectives.

Because the number of tweets containing these words has risen dramatically in recent years, we presented the content trend in two charts, one from mid-2015 to the end of 2017 and the other from the beginning of 2017 to mid-2020, to better illustrate the scales. During this process, an attempt was made to identify issues that could lead to a semantic shift in the aftermath of Kiarostami's death or the COVID-19 outbreak and consider their impact on the research's main topic - the concept of medicine. The issues that cause a sudden increase in tweets can be divided into four categories after identifying and analyzing the findings: 1- Medical and student issues (i.e., the protest against increasing medical students' educational capacity), 2-Indirect political issues affecting physicians (i.e., the protest against Arash's medical condition in prison), 3- Indirect criminal issues that affect physicians (i.e., the protest against sexual harassment), and 4- Serious issues affecting physicians (i.e., Kiarostami death and COVID-19 outbreak).

Finally, after examining the chart's peaks and the topics on which medical tweets have increased, we discovered that no topic related to treatment or the general public, as in the third and sixth periods, could alter the overall trend of tweet volume. A notable point to note is that immediately following Kiarostami's death, the volume of content related to keywords increased, and the average number of tweets increased from 55 to 115 (Figure 1). Additionally, the chart demonstrates that the total volume of tweets increased following the COVID-19 outbreak, and the average number of tweets increased from 1171 to 6823.

4. Method

Data collection and research timeframes

Because the purpose of this study is to analyze the emotions surrounding medicine and physicians and to identify changes in the sensory space of Persian Twitter users' perceptions of this field (as a result of Abbas Kiarostami's death and the spread of the COVID-19), the longitude study enables us to observe shifts in public opinion before and following these events. To create a comprehensive timeline, we gathered data from dates when physicians were in the spotlight. As a result, three of our six timeframes are

centered on national physicians' day; the fourth timeframe is centered on the nine days preceding Kiarostami's death and the nine days preceding his funeral; the fifth timeframe is centered on one year after the incident, and the sixth timeframe is centered on seven months following the COVID-19 outbreak. These six periods enabled us to investigate both short- and long-term shifts in public opinion.

After establishing the research timeframe, we selected relevant Persian hashtags. Hashtags facilitate discussion about a particular subject [42]. Notably, we chose neutral-meaning hashtags to avoid bias in the data. For example, we omitted hashtags containing the words' error' or 'congratulation,' which are likely to convey negative or positive sentiments about physicians. As a result, keywords such as 'Doctor/Doctors, Medical, Specialist doctor, Office/clinic, Treatment, Hospital, Medical System, Medical Record, Patient, Emergency, Nurse, Physician Day' were chosen (in Persian). Finally, we collected 131507 tweets. Twitter Premium Search API (application program interface) Help to extract tweets after identifying the keywords. From August 2015 to August 2020, data were collected in six timeframes, as shown in Table 1.

Sentiment analysis process

Numerous studies have introduced new techniques for analyzing emotions. One of the proposed methods for sentiment analysis is a RULE-BASED APPROACH, as Kawathekar and Kshirsagar (2012) explained in their research. A baseline was created using lexical rules by tokenizing each sentence in each document and then testing each token or word for its presence within the compiled General Inquirer dataset. The Rule-Based approach requires defining rules that contain an antecedent and an associated consequent that have an if-else relationship. Specific rules must be developed for this methodology, and then sentiments must be analyzed in accordance with them. The advantage of a rule-based approach is that it eliminates the need for training materials [43].

The primary benefit of rule-based sentiment analysis is that it requires few preconditions. Thus, in the current study, the rule-based method was combined with the Adu (2016) solution [44] (a step-by-step guide for analyzing data from social media in NVivo) (Figure 2) to analyze the text of tweets using NVivo12 [45]. Due to the nature of the Persian language and research requirements, modifications to these methods have been necessary, as explained in the following research method.

The first phase extracted a total of 131507 tweets, of which 46440 were from the first five periods surrounding Kiarostami's death and 85067 from the COVID-19 outbreak period. We analyzed all tweets, including the most popular tweets and retweets during the specified periods. Retweets have been popular because they contain repetition of content that has been 'republished value' by the user. As a result, retweets are included in the final analysis section in addition to the original tweets.

Table 1. Periods of Study

| Period	Timeframe	Nature of variable	Nature of interval	Number of days
First Period	August 20, 2015 - August 28, 2015	Benchmark status 1	National Physicians' day: August 23, 2015	Nine days in each period
Second Period	March 10, 2016- March 19, 2016	Benchmark status 2	Nine days before Kiarostami's' illness	
Third Period	July 2, 2016 - July 10, 2016	Intervention point: intervening variable	Nine days leading up to Kiarostami's' funeral	
Fourth Period	August 18, 2016 - August 26, 2016	Changing status 1: Measuring the change of signs following a brief period of transition	National Physicians' day: August 22, 2016	
Fifth Period	August 17, 2017- August 25, 2017	Change status 2: Measuring the change of signs following an extended period of transition	National Physicians' day: August 23, 2017	
Sixth Period	August 18, 2020- August 26, 2020	Change status 3: Measuring the change of signs following the completion of 3 years of period 5 (approximately seven months after coronavirus outbreak)	National Physicians' day: August 22, 2020	
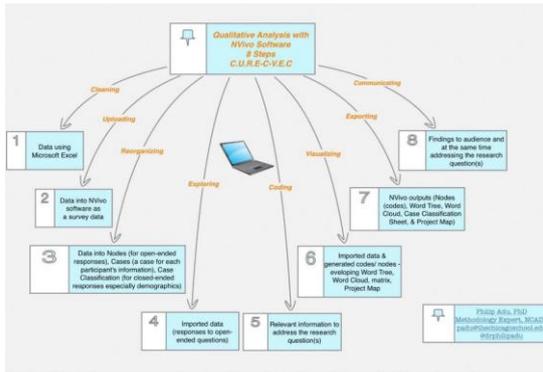
Figure. 2.   Qualitative analysis with NVIVO software in 8 steps [44]

The second step involved data preprocessing. This stage necessitated two steps. The first step was to eliminate non-functional words via stop words; the second step was to identify words associated with positive and negative emotions and the words' value and credibility.' Given that natural language processing methods in Persian are not as precise and descriptive as those used in English, we chose to identify the words in this study's emotional approaches through induction and by referring to the published tweet itself.

In this regard, we created a list of all the words used in the tweets using NVivo's word extraction tool. Along with registering non-functional words in Stop Words and merging similar words, we examined the entire list of extracted words to generate a final list of words associated with each of the three emotion categories mentioned. Indeed, by listing the words associated with the meaning of each emotion (negative, positive, value, and credibility), we were able to generate a comprehensive list of the most frequently repeated terms associated with each category mentioned in the tweets. Table 2 contains the extracted list of words for each emotion category. The extracted terms are classified according to their conceptual similarity.

By preparing the data and performing the preprocessing stage, we advance to the third stage of the current research's methodological process, which is text processing to analyze sentiments. As mentioned previously, this study analyzes emotions using a RULE-BASED APPROACH in conjunction with the Adu (2016) method for Qualitative Analysis of Social Media (Twitter) Data. Overall, there are three different types of text processing that have been used in research to analyze emotions: 1) analysis based on extracting the frequency of words and calculating the coefficient of variation, 2) extraction of Word Cloud to understand the overall lexical space, and 3) extraction of Word Tree to understand the context in which emotionally

Table 2. Sentimental words dictionary

Negative	Positive	Value, credibility, and place of conflict
Error Negligence Mistake	Congratulations Happy	Trust Obligation Conscience Honor Respect

charged words were published; through the connection between the word related to the sense and the words and phrases before and after it.

The first and most traditional method for extracting aspects is frequency-based analysis [46]. A study on the use of pronouns in-group identity consolidation illustrates the frequency-based approach in action [47]. The first type of processing involved developing rules based on the extracted words to generate a query for each emotion (positive, negative emotions, and the terms' value and credibility'). The different spellings of each word in the final list of each emotion category were considered and the 'OR' query rule. For example, 'خطا OR #خطاها OR خطاها OR #خطای OR خطای OR #خطاها OR خطاهای OR #خطاهای' among others.

Finally, the total number of words used in each period was calculated based on the frequency of each extracted query. Along with determining the frequency of words in each period, the coefficient of variation of those words was calculated and illustrated at any time for the total Persian language tweets and tweets about medicine, where $CV(\alpha)$ is the coefficient of variation of the number of tweets between two consecutive periods and $NT(period)$ indicates the number of tweets sent during each period.

$$CV(\alpha) = \frac{NT(period\ \alpha)}{NT(period\ \alpha-1)} \qquad (1)$$

Thus, according to the research program, the data were analyzed in the first step of the word processing section using lexical frequency regardless of text context, and then longitudinal trends in the frequency of words used in Twitter users' discussion were examined. The second and third processing modes were created to summarize texts and analyze emotions. Both of these processes are carried out in NVivo using the word cloud and word tree tools. The second type, which was based on the use of word clouds, achieved the general conceptual space that governs each period by illustrating which words and concepts became popular during that period.

We used the word tree to illustrate and better understand the emotions expressed in the tweets in the third type of text processing, based on the rules

used in the first type of text processing. As a result of this type of processing, emotionally charged words are published in context and concerning other words and phrases, allowing for the crossing of the line between quantitative and qualitative analysis and the achievement of deeper analyses. Finally, by illustrating each of these processes, we attempted to understand the emotions and conceptual space associated with each of the periods discussed in the findings and conclusion section.

5. Results

5.1. A Summary of all Extracted Data for Various Periods

According to Figure 3, the number of medical-related tweets not only peaked in the third period but also steadily increased until it peaked during doctors' day in 2020. It is necessary to consider the proportion of tweets about medicine to the total volume of Persian tweets. This mitigates the possibility of bias as a result of the study's exclusive focus on medical-related tweets. The purpose of Figure 4 is to determine the coefficient of variation (CV) for both categories of tweets over successive periods. As the chart indicates, the CV of the total volume of Persian language tweets in the first and second periods is less than 1, indicating a negative growth in the volume of tweets. However, the volume of medical tweets has increased slightly over these two time periods.

Between the second and third periods, the CV for medical tweets is 2.39, while the total number of Persian language tweets has remained stable and has only recently returned to the level seen in 2015. The third period's high CV is unambiguously related to the death of Kiarostami, which played a significant role in increasing the volume of medical-related tweets.

The incremental coefficients of both categories are nearly identical in the third and fourth periods. As a result, a positive correlation between them can be detected; however, there is an increase in medical-related tweets. It is critical to note that the volume of tweets about medicine has not returned to pre-Kiarostami levels. This indicates that the debates over physicians persisted following the incident, remained unchanged over time in the short term (fourth period), remained stable over time in the long term (fifth period), and did not revert to the previous state. The CVs of the fourth and fifth periods are very similar. This means that the total volume of tweets in Persian and tweets about medicine has nearly doubled. Figure 4's final section evaluates the CV between the 'sixth and fifth periods.'

The chart indicates that seven months after COVID-19, the volume of Persian tweets increased nearly sevenfold, while the volume of medical tweets increased approximately fourfold. As is well known,

Persian tweets have grown in popularity faster than medical tweets. This upward trend can be explained by the fact that the sixth period began three years after the fifth and ended with the appearance of the COVID-19. Given the recent popularity of Persian Twitter and the growth of Persian-speaking users [48], the increase in Persian tweets over the last three years (from 2015 to 2020) exceeds the increase in total medical tweets over the same period.

Overall, the data above indicate that the Kiarostami death and COVID-19 outbreak had a noticeable impact on medical discussion within the Twitter community. It is necessary to investigate whether or not the increased discussion of Kiarostami's death and the spread of the COVID-19 has altered the perception of Persian Twitter users toward medicine and physicians.
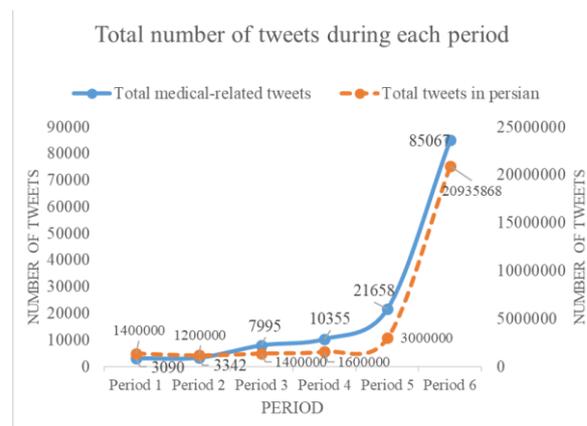

Figure. 3. A summary of the data extracted (sum of medical-related tweets) over various periods, along with the total number of Persian-language tweets
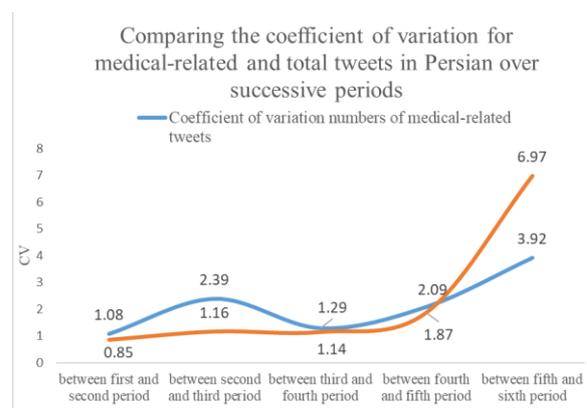

Figure. 4. Comparison of the coefficient of variation in the total number of tweets published in Persian with the coefficient of variation in the number of medical-related tweets over successive periods

5.2. The First Type of Processing: Frequency-based Analysis & CV

Usage of the 'negative' vocabulary

To investigate the use of negative words, we developed Figure 5a, which shows the frequency of negative words across all ratios. Figure 5a depicts the increasing volume of negative tweets following Kiarostami's death. This increase is significantly greater than the trend in the total number of medical-related tweets. The most negative tweets are associated with the 'error' sign and its attachments, while the second-most negative tweets are associated with the 'mistake' sign and its attachments. Each of the three negative indicators (error, mistake, and negligence) significantly decreased during the fourth period, following a sharp increase in Kiarostami's death period. However, the number of negative signs increased during the fifth course. This is especially true for indicating 'error' and a plurality of 'sum of negative signs.' The fifth period's incremental trends in negative tweets are consistent with the overall volume of medical-related tweets increasing. However, during the sixth period, the trend of increasing the frequency of medical tweets outpaced the incremental trends of negative symptoms, except for the 'mistake' sign and its attachments, which had a similar upward slope to the rest of the medical tweets.

Even though the negative signs in the fourth period were significantly reduced compared to the third period, they did not revert to their third-period levels. It is critical to note that there is no change in the number of negative signs between the first and second periods (a sign of the data's reliability) before the intervention of Kiarostami's death as a variable.

While Figure 5a compares sign frequencies, the overall effect of a period's data growth on a sign's increasing or decreasing trend is unclear. For example, in Figure 5I, the 'mistake 'sign appears to have increased significantly, but it is unclear whether this increase is due to the sign's unexpected growth or the overall trend of Persian tweets increasing. As a result, Figure 5b was constructed in terms of the frequency of each sign relative to the total number of tweets during that period to account for the effect of the overall growth of tweets in the computations. As illustrated in Figure 5b, the indicators of 'error,' 'mistake,' and 'negligence' have increased significantly in comparison to the third period's tweets. The fourth period saw a reversal of this incremental trend, and the fifth period saw only an increase in the 'error' sign. Finally, as illustrated in Figure 5b, nearly all negative symptoms subsided and followed the general trend of medical tweets during the sixth or COVID-19 period.

To help visualize the changes in each period relative to the previous period, we divided the numbers recorded for each period in Figure 5c by our previous period in Figure 5b to highlight the increasing or decreasing ratios. In summary, as with Figure 5b, the incremental trend of negative signs is more significant in the third period (Kiarostami) than in the other periods, indicating the negative construction of medicine during the Kiarostami period. Additionally, this chart clearly shows the decline in negative signs during the sixth period (COVID-19).

Usage of the 'positive' vocabulary

Between 2015 and 2017, the increasing trend of positive signs such as 'Congratulations' and 'Happy' followed a linear trend during national physician's day. This incremental trend is consistent with the overall increase in the volume of medical-related tweets on a broader scale. The analysis of data from the CV for 'Happy or Congratulations' over the five years revealed that this sign increased by more than 37 times, most of the increase occurring between the fourth and sixth periods. This sign is used 1.37 times more frequently than the total number of medical-related tweets. While negative indicators have increased significantly after Kiarostami's death, positive indicators have also increased. This increase, however, is not uniform. It is much less than the increase in negative words, most notably 'error.'

Usage of the words with 'value, credibility and place of conflict'

According to Figure 5c, although the words of 'value, credibility and place of conflict' were absent and unused during the first and second periods, it is clear that the increase in physician-related tweets during the third period, as well as the location of conflict over the medical error, increased the tweets with the words with semantic value located in the place of conflict.

This is confirmed in Figure 6a, which depicts the use of these terms in tweets from that period. Compared to the rest of the keywords, the rate of incremental variation for this category of words is most pronounced for the sign of 'conscience' and, in particular, 'honor.' As illustrated in Figure 6b, the 'Honor' sign and its affiliations began a sharp upward trend in periods 3 and 4, allowing it to maintain a significant distance from the overall upward trend in tweet volume. This upward trend ceased at the fifth period's intersection, but as Figure 6a and 6b demonstrate, the level of use of this sign in periods five and six remains significantly higher than that of other symptoms.

Figure 6a demonstrates a dramatic increase in the total volume of value signs used in the sixth period. To better understand why this increase occurred, it is necessary to examine Figure 6b, which illustrates the usage of the terms' value and place of conflict' concerning the volume of tweets published during
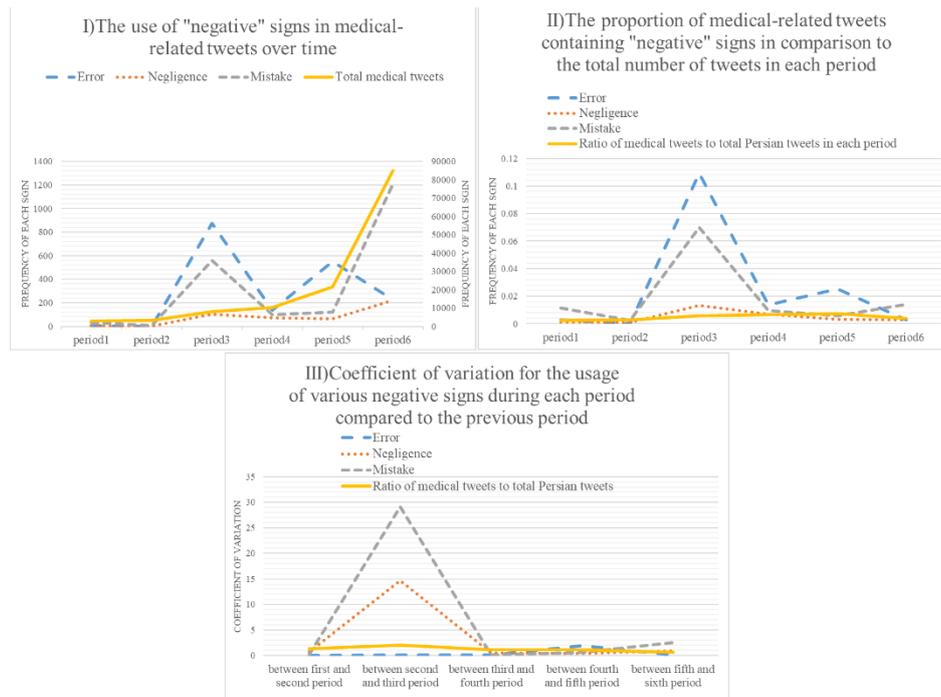
Figure. 5.   a. The frequency with which "negative" signs appear in medical tweets over time; b. The frequency with which "negative" signs appear in medical tweets in relation to the total number of tweets in each period. c. The coefficient of variation value of each period's usage of different negative signs in comparison to the previous period

that period. As illustrated in Figure 6b, despite an overall increase in value signs during the sixth period, this increase was consistent with the overall volume of Persian tweets; thus, it does not seem to be relevant to the location of value symptoms re-confliction with the medical field and physicians.

To help visualize the changes that occurred during each period compared to their preceding and subsequent periods, Figure 6c was created. This figure, obtained by dividing the numbers recorded for each period in Figure 6b by our previous period, clearly shows that the signs are ascending in the third and sixth periods. In comparison to the second period, the signs of 'obligation,' 'respect,' and 'trust' have increased significantly beyond the total number of Persian tweets in the third period. The volume of value signs increased slightly in the fourth period compared to the third, but not as significantly as in the previous period (third to second). As can be seen, the differences between the sixth and fifth periods (Coronavirus period) indicate an increase in the signs of 'trust' and 'obligation' to the general trend of Persian tweets.

Given the nature of value signs, it is argued that when these words are in a meaningful incremental channel, they are entangled in a semantic transformation and discourse conflict that may have obliterated their previous semantic process. To comprehend this, we must examine what other words

and phrases are included in a macro-scale to determine the sign's changes.

5.3. The Second Type of Processing: Word Clouds

The word cloud for each period is depicted in Figure 7. As previously stated, the first period was chosen to coincide with the year before Kiarostami's death and with physician's day in 2015. Throughout this period, the word 'congratulations' is emphasized alongside neutral terms such as treatment and health. In the second period, nine days before Kiarostami's death, there is no clear indication of whether public opinion is positive or negative; however, in the third period, nine days before Kiarostami's funeral, the terms Kiarostami, imprisonment, and strike have been highlighted, indicating the significance of the medical error that occurred to Kiarostami and the negative perception towards physicians.

The word 'congratulations' was frequently used during the fourth period, which began one year after Kiarostami's death. A year later, in the fifth period, the terms' congratulations,' 'Karroubi (politician),' and 'strike' were frequently used, indicating that there has been no disagreement about how the public views medicine and physicians during these periods, and debates remain within the scope of Physician Day greetings. Finally, three years later, in the sixth period, and as a result of the COVID-19 outbreak, it can be seen that the terms hospital, medicine, physician, treatment, patient, and COVID-19 are highlighted differently than other terms, indicating
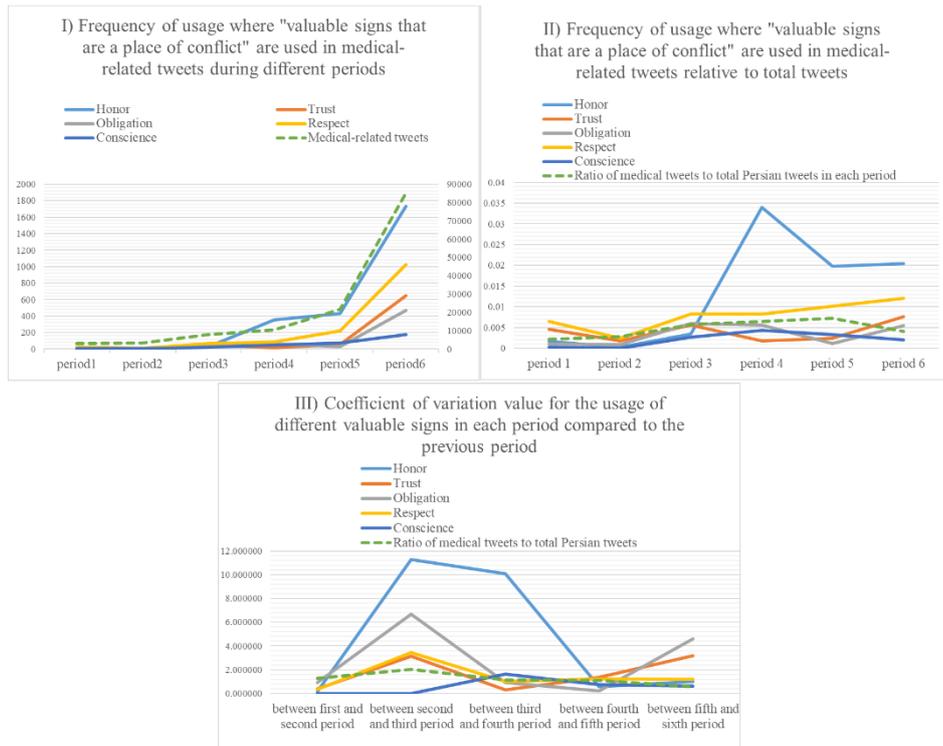
Figure. 6.   a. Frequency of usage where "valuable signs that are a place of conflict" are used in medical-related tweets during different periods, b. Frequency of usage where "valuable signs that are a place of conflict" are used in medical-related tweets relative to total tweets c. Coefficient of variation value for the usage of different valuable signs in each period compared to the previous period
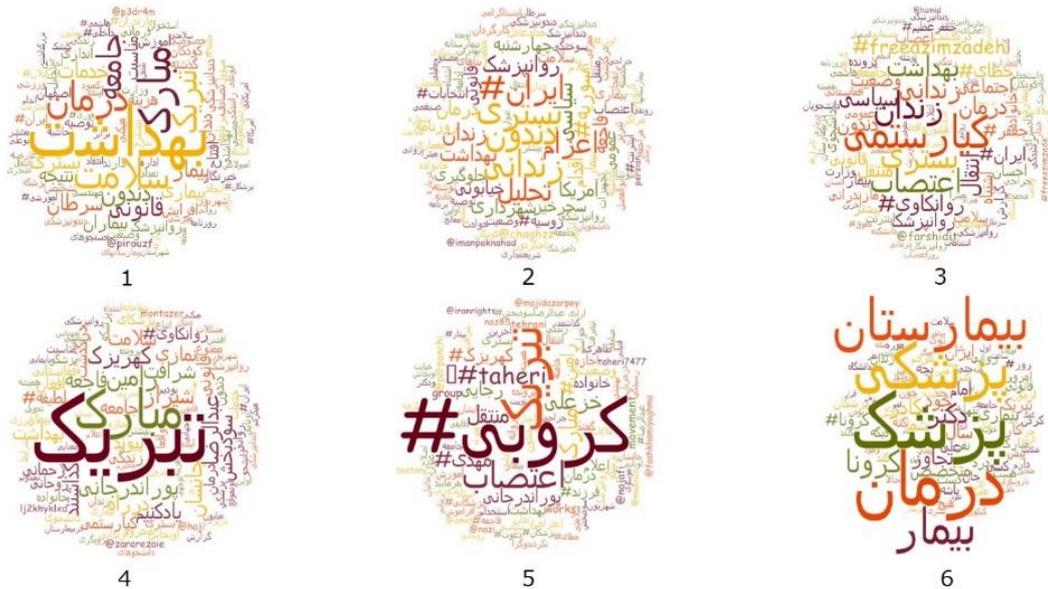
Figure. 7.   Word cloud for each period

the growing importance of medicine and physicians, as well as public attention to these issues. From all of the word cloud images, it is clear that in the third and sixth periods, the general perception of medicine and physicians became a source of contention, and public discourse during these periods placed a premium on this issue.

It is necessary to consider the context in which the emotionally charged words were published to understand the extracted data better. The following section attempts to shed light on this subject by visualizing the word tree and summarizing the texts.

5.4. The Third Type of Processing: Word Trees

We examine the nature of the changes in the mentality of Twitter users in the field of medicine and physicians in Iran and attempt to comprehend the epistemic shifts in this area. According to the graphs in Figure 8, the symbolic relations reveal the hidden meanings in the texts. Through quantitative analysis of the data and their coexistence, more in-depth analysis can be accomplished using these graphs. It should be noted that the aggregation of word tree diagrams in Figure 8 is solely to provide an overview of the results of small-scale analysis; the main diagrams are included in the appendix for further study.

In the third period, the concepts of 'error' and 'medicine' were connected, resulting in the formation of a new structure. Figure 8 illustrates the combination of these two signs and their strong relationship. This connection is evident in the fourth and fifth periods. Evidently, Kiarostami's death had a profound effect on the epistemic field of physicians, which persisted more than one and a half years later - albeit diminished. However, the graphs for the first and second periods (Figure 8) indicate that there is no hegemony in the association between 'error,' 'mistake,' and other negative terms referring to physicians. Colocations such as 'Medical blunder' and 'medical error' (Figure 8) were communicated to physicians following the third period.

Even though the fourth and fifth periods emphasize the 'errors,' 'negligence,' and 'mistakes' of doctors, those periods are connected to and commemorate doctor's day. However, using all of these negative words does not preclude a flood of positive words such as 'Congratulations' on doctor's day and the terms medical and physician.

As previously stated, the use of sign words with semantic significance has increased significantly since the third period and has continued through the fourth and fifth periods. A new understanding of their nature can be gained with precision in the details of the connections between these keywords and other signs (Figure 8).

The presence of a link in a doctor's epistemic domain is influenced by the social reconstruction of 'error' as one of the most intimate signs of medical and physician knowledge. The term 'medical error' was coined after Kiarostami's death, which sparked a debate over previously accepted values among physicians.

In the sixth period, in response to the COVID-19 pandemic, the construction formed by medicine and physicians shifted again compared to what had occurred following Kiarostami's death, and the use of positive words supplanted the use of negative words. Compared to previous periods, the two signs of 'error'

and 'negligence' have less concentration in the new period, indicating no severe conflict over these signs.

In contrast to other negative indicators, the 'mistake' sign increased in the sixth period. A noteworthy feature of this sign's tree graph is the variety of justifications offered for the errors that occurred. For instance, some users attributed the error to human nature and the medical profession, while others speculated on the possible effect of medication on a physician's erroneous decisions. On the other hand, some users described the physician's error, particularly in diagnosing the disease, as a category that is buried underground, leaving physicians with no avenue for pursuing and punishing. In this regard, it can be argued that the sign of 'honor' and its associations, which had been discussed throughout the increasing process influenced by Kiarostami's situation, remained stable in the sixth period. During this period, medicine emerged from a conflict over whether it was superior or inferior to other professions and was introduced alongside all other honorable professions.

Comparing the current word tree to its counterpart from the previous period reveals that the 'honorable' sign had the highest frequency among its related attachments during this period. Thus, the word tree is not based solely on the word 'honor' (dishonorable doctor, honorable physician) (as was the case in the period following Kiarostami's death), but also on the word 'honorable' (honorable doctor, decent job, and honorable man).

The comparison of the term 'trust' in the Kiarostami and Coronavirus periods confirms the dual structure of valuation in previous periods, with the exception that in the Coronavirus period, 'giving value' precedes 'not giving value,' and a better discourse space for physicians was created as a result of the strengthening of the discourse of modern medicine.

As illustrated in Figure 8, the new era's word 'obligation' sign tree has also developed around the concept of committed physicians, and praise and congratulations from physicians who possess both commitment and expertise are plentiful. Examining the sign of 'respect' during the Coronavirus period reveals that people have greater regard for doctors than previously and, like other value indicators during the sixth period, confirm the positive discourse shift toward physicians.

6. Discussion

The results of this study highlight significant changes in public sentiment toward medicine and physicians in response to two critical health events: the death of Abbas Kiarostami due to a medical error and the COVID-19 pandemic. These findings provide novel insights into the dynamic interplay of social

Figure. 8. Set of negative and positive signs in the first to sixth periods of the word tree

events and public perceptions within the Iranian context.

The negative emotions triggered by Kiarostami's death, particularly those associated with "medical error," resonate with findings in previous studies. For instance, Kim et al. (2020) also identified heightened public scrutiny and negativity toward physicians in Australia following media coverage of medical errors [25]. Similarly, the association of terms such as "error" and "negligence" with medicine aligns with studies emphasizing the role of critical events in reshaping trust in healthcare systems (Shafqat et al., 2020) [15].

Conversely, the COVID-19 pandemic marked a shift toward positive sentiment, reflecting increased trust and respect for medical professionals. This finding echoes research by Lwin et al. (2020), who reported global patterns of shifting emotions—from fear to gratitude—toward healthcare workers during the pandemic [18]. The significant increase in words associated with trust and obligation during this period reinforces the idea that collective crises can enhance public appreciation for the medical field, a phenomenon previously discussed in studies on public health crises (Chew & Eysenbach, 2010) [16].

The contrasting trends observed—negative sentiment during Kiarostami's death and positive sentiment during COVID-19—underscore the critical role of public discourse in shaping medical narratives. While earlier studies in the Iranian context have often focused on micro-level interactions, such as physician-patient relationships (Ekhlasi, 2016; Sadati et al., 2016) [28, 32], this research provides a macro-level perspective that captures the broader societal shifts.

Furthermore, the emergence of "value and credibility" as central themes in medical discourse during these events highlights an ongoing negotiation of the medical profession's role in Iranian society. This aligns with Desbiens et al. (2005), who identified similar dynamics in public perceptions of physician professionalism [26]. However, the gradual return to a more balanced narrative during COVID-19 suggests an opportunity for the medical community to rebuild and reinforce its credibility through transparency and effective communication.

This study contributes to the growing literature on sentiment analysis in healthcare by employing a longitudinal approach and focusing on the Persian Twitter context. While challenges in analyzing Persian texts persist (Rajabi & Valavi, 2021) [49], the findings demonstrate the utility of big data and computational methods in capturing complex social dynamics.

Future research should explore how these sentiment trends evolve over time and across other social media platforms, such as Instagram, to develop a more comprehensive understanding. Additionally, investigating the perspectives of healthcare professionals themselves could provide valuable insights into the reciprocal relationship between public sentiment and medical practice.

In conclusion, the study underscores the profound impact of critical events on public sentiment toward medicine, emphasizing the need for proactive engagement by healthcare systems to address concerns and build trust during and beyond crises.

7. Conclusion

The current study sought to ascertain changes in the emotional climate toward medicine and physicians among Twitter users between 2015 and 2020. The study's intervening variables were Kiarostami's death (caused by a medical error during the treatment process) and COVID-19, which caused significant changes in the field of health. Data were collected in six periods (some preceding and some following the primary variable) to assess the variables' short- and long-term effects. The study's broad question was then subdivided into several sub-questions to be addressed in a step-by-step fashion using sentiment analysis.

It was demonstrated that the volume of tweets about medicine and physicians increased exponentially between 2015 and 2020, with the volume of Persian medical tweets reaching an all-time high following Kiarostami's death. Such a difference indicates a significant increase in 'the process of bringing medicine and physicians into the spotlight,' which, in the opinion of Twitter users, can become the focal point of 'the reconstruction of medicine and physicians.' Additionally, investigations have revealed that this disparity shifted in favor of Persian tweets during the sixth period. The total volume of Persian tweets increased significantly compared to medical tweets, which is critical and should be considered in future studies.

Then, it was observed that negative signs increased significantly following Kiarostami's death and were referred to significantly more than the increasing trend of medical tweet volume. The sign 'error' was a frequently used word in tweets. While the rate of positive signs increased over time, it was not comparable to the rate of negative signs increasing. It could be witnessed that terms denoting value and credibility were quite frequently used after the third period.

In terms of the investigated signs' nature (negative, positive, and value and credibility) and their relationship to other signs, it should be noted that negative signs typically accompanied the term 'medical' in the period following the third period, and the construction of the 'medical error' occurred during the same period. Another critical point is that in the majority of signs, the concept of 'value and credibility' has become contradictory, with suffixes such as '-ful' or '-less' used to assign value to medicine and physicians or to deprive them of it. According to sentiment analysis conducted during the sixth period (COVID-19 era), negative and contradictory perceptions toward medicine have shifted and replaced more positive perceptions.

It is critical to note that this study's primary limitation is a lack of robust software and mechanisms for sentiment analysis of Persian texts. The absence of Persian tools and packages, context-based sentiment Lexicons, labeled data, and domain-specific methods makes analyzing Persian research difficult [49]. Additional studies on text mining in medical-related tweets are required to create a complete picture of medicine and physicians on Twitter.

One of the study's limitations is the absence of any discussion of the relationship between medical construction, guilds, and student events in the field of medicine, which is suggested as a future research topic. Along with examining ordinary citizens' perception, examining the semantic changes made by physicians and medical students toward themselves

and the field in which they work and study can aid in a better understanding of the change of medical discourse.

Furthermore, while this article focuses on Twitter, users' perspectives on medicine and physicians on other social media platforms such as Instagram may differ from those found in current research and could be the subject of future studies and research. The contradiction between traditional and modern medicine is another area that researchers should consider more carefully in future research, utilizing computational analysis of big social media data sets.
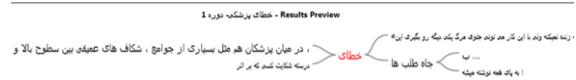
Appendix

Figure. 9.   Word tree- Error in period 1

Figure. 10. Error and Negligence in period 4

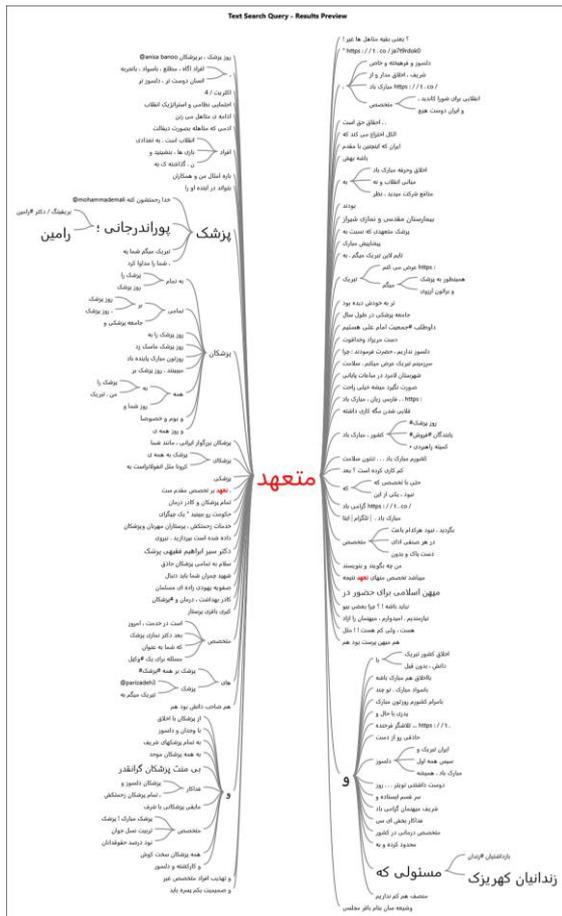Figure. 11. Word trees -Conscience, honor and trust in period 4

Figure. 12. Word trees -Obligation in period 6

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Authors' contributions

AT: Study design, acquisition of data, Data setup, interpretation of the results, statistical analysis, drafting the manuscript;

ME: Study design, drafting the manuscript, revision of the manuscript;

AG: Interpretation of the results, statistical analysis, revision of the manuscript;

FR: Data setup, drafting the manuscript.

Conflict of interest

The authors declare that no conflicts of interest exist.

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