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Using Grey-ARAS Approach to Investigate the Role of Social Media Platforms in Spreading Fake News During COVID-19 Pandemic

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Abstract: Responsible use of social media requires a level of culture and awareness on the part of the user themselves that allows them to understand and absorb the enormous amount of information they receive through these mediums, verify it, and then share it with their friends and users. This leads to numerous problems related to public health and safety. This research aims to identify the most significant effects of the dissemination of fake news in times of crisis on public health and safety, as well as to propose strategies to overcome this phenomenon. A hybrid Grey-ARAS (Additive Ratio Assessment) model was used to rank the potential impacts and propose strategies to overcome them. Four experts in the field of public health, data analysis, and contagious diseases participated in this study to determine the weights. Eight factors affecting public health and safety were proposed, along with seven strategies to mitigate these impacts. The results showed that the most important factors are creating panic and anxiety among people along with the contribution to the misleading public policy decisions. The results also showed that the most appropriate strategies to overcome the impact of fake news are to encourage people to check facts and monitor social media. A sensitivity analysis of the results obtained was also performed, proposing 20 different scenarios to adjust the relative weights of the criteria. The results showed a certain stability when using different scenarios.

Keywords: Fake news; Social media; COVID-19; MCDM; Grey theory; ARAS

1 Introduction

News increases dramatically in times of crisis, with truth mixed with falsehood, especially in light of the rapid exchange of information among social media users and its widespread dissemination, coupled with the lack of official sources and the slow diffusion of information imposed by the process of gathering data and ensuring its validity and credibility before publication. This disparity between the two means creates a wide gap that paves the way for false and unreliable news, whether intentionally or unintentionally, for commercial or propaganda reasons, with the result being misinformation that increases the psychological pressure and negative effects on users, especially in times of crisis. Though fake news is not new, it is now concerning due to the popularity of social media, which allows for interaction and the spread of new ideas. As a result, social media users can advance ideas or spread news through shares, likes, or retweets; as a result, they are invariably exposed to an uncontrollable type of information, particularly news from independent authors. As a result, social media is now a place where misinformation and fake news can spread quickly. It has been demonstrated that social media is a powerful tool for disseminating large amounts of unfiltered content, enabling a misinformation phenomenon and, as a result, increasing the possibility of manipulating the public's perception of reality through the dissemination of fake news content [1]. Fake news is created content that mimics legitimate news and is presented subtly to fool the public into believing it is legitimate.

In today's digital world, the spread of fake news has become rampant. This suggests that some government officials and individuals spread misinformation to a large audience to further their agenda. Thus, fake news has infiltrated nearly every aspect of our lives, with the most concerning recent years being the spread of false content during the coronavirus disease 2019 (COVID-19) outbreak [2]. According to World Health Organization WHO, there were over 763 million COVID-19 cases worldwide as of April 24, 2023, and more than 6.9 deaths were reported. When COVID-19 began to spread in 2019 in China, rumors about the coronavirus quickly spread across the internet,

with conflicting information about the pathogens and modes of transmission. The coronavirus pandemic has caused disruption worldwide, negatively affecting the effectiveness of virus containment strategies, and this information would fundamentally distort the perception of the danger of the virus as it evolves and becomes more dangerous over time [3]. The danger lies in the fact that false information related to the pandemic poses a direct threat to the public health of individuals, as some incorrect information on social media promoting medical treatments for the virus is not based on medical advice, which can lead to serious health complications for their users. Hence, accurate and truthful information on the situation, based on scientific grounds, is urgently needed as a vital source of information and support for medical personnel and health organizations in implementing their strategies to stop the spread of the epidemic.

Due to the novelty of the Corona virus, the lack of scientific research on the causes of its transmission, its effects, and methods of prevention and treatment has effectively contributed to the publication and dissemination of false information, especially on social networking sites [4, 5]. This has also become a global public health problem that negatively affects the ability of governments to mitigate the disease, causing accidental injuries, deaths, and self-harm due to false beliefs about the virus, leading health organizations to refer to the spread of false news about the pandemic as an "infodemic," which poses additional challenges for public health authorities to adapt effective risk communication management strategies. It is becoming increasingly difficult to distinguish between fake news and legitimate reports. As a result, misinformation on social media has fueled public panic about the COVID-19 pandemic, prompting governments and authorities to urge citizens to confirm the veracity of news stories before spreading them [6]. According to research, as the global search for a cure for COVID-19 continues, the spread of fake news on social media has increased, which many experts believe is contributing to the pandemic's threats.

Following the discovery of the first COVID-19 case in Wuhan, China, in December 2019, the pandemic spread throughout the entire world. The first case in Libya was recorded on 24 March 2020, and it took two months for cases to start noticeably rising [7]. The second wave of COVID-19 began to attack on July 20, 2021, more than a year after the first case. It was stronger than the first wave [7]. The Libyan government has taken numerous efforts to control the epidemic's spread. The use of different types of media to educate people is one of these actions. However, a lot of fake information did get to the populace. This false information included the disease's symptoms, treatment methods, and modes of transmission.

Spreading fake news has many impacts on public health and safety. Research in this field is still in its start. In this research, we study the most important impacts of spreading fake news related to the COVID-19 pandemic on public health and safety. The paper also proposes a set of strategies to overcome the false news that is spread on social media. Impacts and strategies are evaluated using multi-criteria decision-making methods.

2 Methodology

Multi-criteria decision making MCDM is a technique utilized by researchers when making decisions involving the prioritization, classification, or selection of preferences. In a proposition requiring consensus, the MCDM system incorporates the behavior of preferences across various quantitative, qualitative, or contradictory criteria and effects. Various disciplines, including information systems, economics, computer applied science, and behavioral decision theory, are utilized. Different MCDM processes have been used effectively in different areas of need [8, 9].

There are different MCDM methods, such as the analytical network process, fuzzy decision-making, and data envelopment analysis. Even though many studies have used these methods, MCDM is still a fast-growing problem area in many research topics. Each approach has the same ability to make decisions when there is a lack of trust, and each has its own advantages.

Deng introduced grey system theory as a mathematical approach for the first time in 1982 [10]. Modeling problems with limited data and integrating uncertainty into systems has been accomplished with success using this theory. The grey theory, unlike traditional methods that require a large number of samples, is designed to analyze and model systems with insufficient information. The grey system theory has been utilized effectively in various research fields, including finance, engineering, social science, and economics. When all information is known, the system is referred to as white, and when all information is unknown, it is referred to as black. It is referred to as a grey system when information is incomplete.

Grey number can be defined as a measure where we only know the range of values rather than the exact value. The discrete or continuous grey numbers represented by the symbol $\otimes$ are used to express the unknown parameters of the grey system. The theory includes a number of characteristics and operations on grey numbers, such as the core of the number $\otimes$, its degree of greyness, or g°, and the degree of whitening of the grey number, which describes how a number tends to be in the middle of a range of possible values. Zavadskas and Turksis [11] created the ARAS technique. It is frequently employed for numerous multi-criteria decision-making problems [12–14].

This research uses a hybrid grey-ARAS method to examine the assessments of decision makers to determine the strategies that could be implemented to address the spread of fake news in social media in Libya. The aim of this research is to implement this hybrid approach to rank seven suggested strategies. The priority weights of

the strategies were determined using MS Excel macros based on the questionnaire forms that were used to compare major attributes and strategies.

The Grey-ARAS model is conducted on eight steps as follows [15–17]:

Step 1: Choosing a set of the most crucial consequences (attributes) of spreading fake news on social media and suggest strategies to counter these consequences.

Step 2: Using the following equations to calculate the weight of attributes W_j:

$$\otimes W_j = \frac{1}{K}\left[\otimes W_j^1 + \otimes W_j^2 + \cdots + \otimes W_j^K\right] \tag{1}$$

$$\otimes W_j^K = \left[\underline{W}_j^K, \underline{W}_j^K\right] \tag{2}$$

Step 3: Experts assess the alternatives: expert's feedback will be on either linguistic or verbal factors depending on the criteria.

$\otimes G_{ij}^K, (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n)$ is the value of the attribute obtained from the kth expert to any of the alternatives which is represented as, $\otimes G_{ij}^K = \left[\underline{G}_{ij}^K, \bar{G}_{ij}^K\right]$ and calculated using the following formula: $\otimes G_j = \frac{1}{K}\left[\otimes G_j^1 + \otimes G_j^2 + \cdots + \otimes G_j^K\right]$.

Step 4: Forming the Grey Decision Matrix:

$$G = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & \cdots & \cdots & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & \cdots & \cdots & \otimes G_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \\ \otimes G_{m1} & \otimes G_{m2} & \cdots & \cdots & \otimes G_{mn} \end{bmatrix} \tag{3}$$

Step 5: Normalizing the Decision Matrix. Beneficial criteria are normalized with linear normalization procedure as follows:

$$xij^* = \left[\frac{x_{ij}}{\sum_{i=1}^m x_{ij}}\right] \tag{4}$$

Non-beneficial criteria are normalized with two-stage procedure. In the first stage the reciprocal of each criterion with respect to all the alternatives is taken as follows:

$$xij^* = \left[\frac{1}{x_{ij}}\right]$$

In the second stage, the normalized values are calculated as follows:

$$R = [rij]_{n*n} = \left[\frac{xij^*}{\sum_{i=1}^m {x_{ij}}^*}\right]$$

Step 6: The normalized decision matrix is weighted as follows:

$$\mathrm{D} = [d_{ij}]_{n*n} = r_{ij} * w_j$$

where, w_j is the weight (importance) of jth criterion.

Step 7: The optimality function (Si) is determined for each alternative as follows.

$$Si = \sum_{i=1}^{n} d_{ij} \tag{5}$$

The highest and lowest Si values are the best and the worst respectively. The optimality function Si has a direct and proportional relationship with the values in the decision matrix and criteria weights. S0 is the optimality function of the optimal alternative.

Step 8: The degree of the utility (Ui) is determined for each alternative. It is calculated as follows:

$$Ui = \frac{Si}{S0} \tag{6}$$

In this method, a utility function value determines the relative efficiency of an alternative over the best alternative. The Ui values of alternatives range from 0% to 100% and they are placed in ascending order. The alternative with the highest utility value is the best choice among the alternatives.

3 Results

In this research study, qualitative criteria for the fake news consequences for public health and safety during COVID-19 pandemic in Libya are studied. Table 1 shows the seven different consequences that are considered. All these criteria are classified as cost criteria. The model was programmed using macros in Microsoft Excel to make the procedure easier.

Table 1. Criteria used

Criteria	Description
Undermining public health efforts (C1)	False information about COVID-19 can undermine public health efforts by causing people to disregard public health guidelines and recommendations.
Promoting dangerous treatments (C2)	Fake news may promote dangerous or ineffective treatments for COVID-19, leading people to take actions that could harm their health.
Creating panic and anxiety (C3)	Misinformation can cause panic and anxiety, leading to increased stress and potentially worsening mental health outcomes.
Misleading public policy decisions (C4)	If policymakers are influenced by false information, it can lead to ineffective or counterproductive public policy decisions that may exacerbate the spread of the virus.
Encouraging discriminatory behavior (C5)	Misinformation can fuel discriminatory behavior towards certain groups, leading to further division and stigmatization.
Reducing trust in public institutions (C6)	Repeated exposure to false information can lead to a decrease in trust in public institutions, including healthcare providers, public health agencies, and government authorities.
Increasing the spread of the virus (C7)	Fake news can encourage risky behaviors that increase the spread of the virus, such as attending large gatherings or not wearing a mask.
Hindering vaccine uptake (C8)	False information about COVID-19 vaccines can lead to vaccine hesitancy, which can slow down efforts to achieve herd immunity and end the pandemic.

Four experts were invited to evaluate each of the proposed criteria in the examination of their impacts on public health and safety. Table 2 shows a scale that can be used to express linguistic variables in grey numbers.

Table 2. The importance of grey number for the weights of the criteria

Importance	Abbreviation	Scale of grey number $\otimes$ W
Very Low	VL	[0.0, 0.1]
Low	L	[0.1, 0.2]
Medium Low	ML	[0.2, 0.3]
Medium	M	[0.3, 0.4]
Medium High	MH	[0.4, 0.6]
High	H	[0.6, 0.8]
Very High	VH	[0.8, 1.0]

Table 3 summarizes the expert responses in evaluating the targeted attributes. Weights of attributes are calculated using Eq. (2).

Table 3. The linguistic assessment of the attributes by experts

Ci	Expert #1	Expert #2	Expert #3	Expert #4	$\otimes$ W		Whitening degree
C1	MH	VH	H	M	0.53	0.70	0.6125
C2	MH	H	MH	MH	0.45	0.65	0.5500
C3	H	VH	VH	VH	0.75	0.95	0.8500
C4	VH	H	VH	VH	0.75	0.95	0.8500
C5	MH	H	H	M	0.48	0.65	0.5625
C6	H	H	H	M	0.53	0.70	0.6125
C7	H	H	M	M	0.45	0.60	0.5250
C8	H	H	ML	L	0.38	0.53	0.4500

As presented in Table 3, the third and fourth criteria, which denote to the creating panic and anxiety and

misleading public policy decisions, are ranked as the top priority among all criteria followed by the undermining public health efforts and reducing trust in public institutions criteria. This perhaps illustrates the dangers of fake news causing panic among the population, which affects the confidence of citizens in the decisions made by the various public institutions. Table 4 shows the suggested strategies to overcome the consequences of fake news on social media.

Table 4. Suggested strategies

Strategies	Description
Education and awareness campaigns (S1)	It is important to educate people about the dangers of fake news and how to identify it. This can be done through social media campaigns, public service announcements, and workshops. People need to be made aware of the consequences of sharing fake news and how to verify information before sharing it.
Encourage fact-checking (S2)	Social media platforms can encourage fact-checking by providing resources and tools to help users verify information. They can also work with fact-checking organizations to identify and label fake news.
Collaborate with media outlets (S3)	Social media platforms can work with traditional media outlets to ensure that accurate and reliable news is shared. This can include partnerships with local newspapers and television stations to promote accurate reporting.
Strengthen regulations (S4)	Governments can create laws and regulations that require social media platforms to act against fake news. This can include fines for platforms that fail to remove fake news or require platforms to label posts that are potentially misleading.
Improve media literacy (S5)	It is important to teach critical thinking skills and media literacy to young people in Libya. This can be done through school programs and community initiatives.
Encourage responsible sharing (S6)	Social media users need to be responsible for what they share. Encouraging users to check the source of information and verify the information before sharing it is essential to combat fake news.
Monitor social media (S7)	Finally, it is important to monitor social media platforms to identify and remove fake news. This can be done through automated tools that detect patterns of false information, or by human moderators who review posts and flag those that are potentially misleading.

After the suggested consequences' weights were calculated, the strategies are ranked using ARAS method. Based on the experts' opinions, an initial decision matrix was prepared (Table 5).

Table 5. The initial decision matrix

Weights	**0.122**	**0.110**	**0.170**	**0.170**	**0.112**	**0.122**	**0.105**	**0.090**
Strategy	**C1**	**C2**	**S3C3**	**C4**	**C5**	**C6**	**C7**	**C8**
S1	72	77	87	65	57	65	62	67
S2	65	72	67	72	62	57	50	80
S3	67	75	75	70	67	62	65	92
S4	75	62	67	67	65	70	62	82
S5	75	77	72	75	70	67	62	87
S6	70	62	80	72	65	65	52	80
S7	70	70	70	67	62	62	50	77

After that, the data is normalized (Table 6). The normalization is conducted using a simple linear normalization. Since all criteria are of cost type, the maximum value of the criteria is calculated.

Table 7 shows the weighted normalized decision matrix.

The optimality function (Si) and the utility degree (Ui) of each alternative is calculated using Eq. (5) and Eq. (6) respectively. Si and Ui values and the ranking of the alternatives are presented in Table 8. Table 7 shows the rank of the proposed strategies. The second strategy, encouraging fact-checking, comes out on top. This encourages any person or organization to validate a news item before sharing it. The sharing of fake news is the main factor in the spread of fake news, and encouraging people to check the veracity of news and share only accurate information will reduce the flow of fake news. Monitoring of social networks comes second, as it will also prevent or limit the spread of fake news.

Table 6. The normalized decision matrix

Weights	**0.122**	**0.110**	**0.170**	**0.170**	**0.112**	**0.122**	**0.105**	**0.090**
Strategy	**C1**	**C2**	**S3C3**	**C4**	**C5**	**C6**	**C7**	**C8**
S1	0.140	0.130	0.121	0.153	0.160	0.140	0.131	0.171
S2	0.155	0.139	0.157	0.138	0.147	0.160	0.163	0.143
S3	0.150	0.134	0.140	0.142	0.136	0.147	0.125	0.124
S4	0.134	0.162	0.157	0.148	0.140	0.130	0.131	0.139
S5	0.134	0.130	0.146	0.132	0.130	0.136	0.131	0.131
S6	0.144	0.162	0.131	0.138	0.140	0.140	0.156	0.143
S7	0.144	0.143	0.150	0.148	0.147	0.147	0.163	0.148

Table 7. The weighted normalized decision matrix

Weights	**0.122**	**0.110**	**0.170**	**0.170**	**0.112**	**0.122**	**0.105**	**0.090**
Strategy	**C1**	**C2**	**S3C3**	**C4**	**C5**	**C6**	**C7**	**C8**
S1	0.017	0.014	0.020	0.026	0.018	0.017	0.014	0.015
S2	0.019	0.015	0.027	0.023	0.016	0.019	0.017	0.013
S3	0.018	0.015	0.024	0.024	0.015	0.018	0.013	0.011
S4	0.016	0.018	0.027	0.025	0.016	0.016	0.014	0.013
S5	0.016	0.014	0.025	0.023	0.015	0.017	0.014	0.012
S6	0.018	0.018	0.022	0.023	0.016	0.017	0.016	0.013
S7	0.018	0.016	0.025	0.025	0.016	0.018	0.017	0.013
Sum	0.019	0.018	0.027	0.027	0.015	0.017	0.019	0.019

Table 8. The relative assessment matrix and the assessment scores of alternatives

Strategy	**Si**	**Ui**	**Rank**
S1	0.142	0.873	5
S2	0.150	0.923	1
S3	0.138	0.851	6
S4	0.144	0.884	3
S5	0.135	0.828	7
S6	0.143	0.880	4
S7	0.149	0.915	2

To verify the findings, further analysis was done on the input parameters. For 20 alternative scenarios (Set 1–Set 20), simulated weights were determined using Eq. (7), which is based on the most crucial criteria C3 & C4.

$$w_{n\boldsymbol{\beta}} = (1 - w_{n\boldsymbol{\alpha}}) \frac{w_{\boldsymbol{\beta}}}{(1 - w_n)} \tag{7}$$

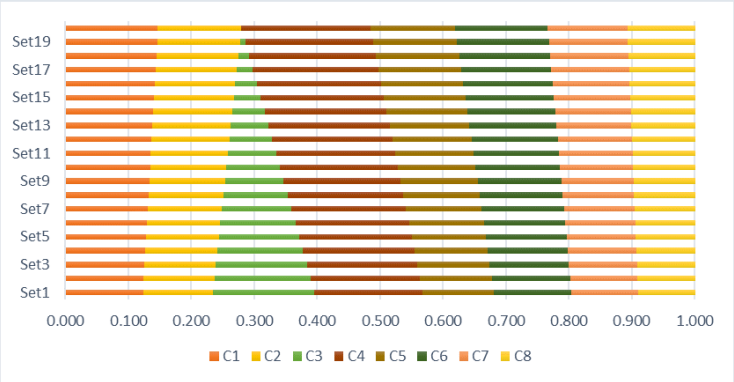

Figure 1. Criteria weights under 20 scenarios

In this formula, $w_{n\beta}$ represents the altered weights of the criteria, whereas $w_{n\alpha}$ represents the decreased weight of the most significant criterion. w_{β} represents the initial weight of each criterion, whereas w_n represents the original weight of the most important criterion. For C3, the most important criterion, the rate of reduction was decreased by 5% in each scenario [18], and the application was finalized through 20 scenarios. Figure 1 displays simulated weights for criteria.

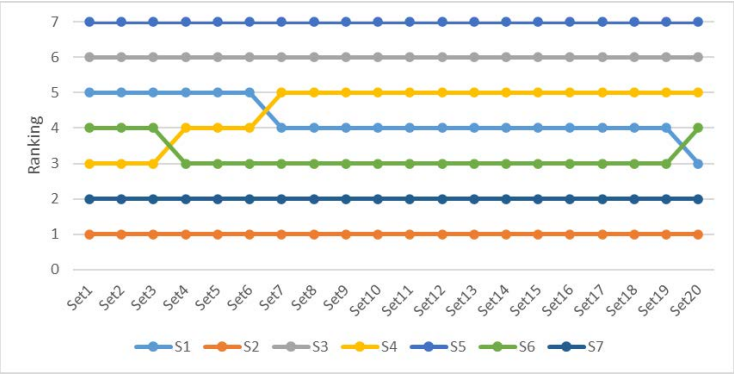

Figure 2. Scenario-based rankings through 20 scenarios

Figure 2 shows scenario-based rankings using simulated criteria weights. As a result, changes in the weighting of the criterion will not affect the ranking significantly. While S3 and S4 share rank third and fourth in different scenarios, S2 is always the best strategy. Overall, sensitivity analysis using simulated weights showed stable results due to its high level of consistency.

4 Conclusions

Fake news constituted a new epidemic in light of the pandemic of COVID-19, according to the WHO, which called it the infodemic, and hence these news constituted a real threat to public health and safety in the world, and the lack of sufficient information about the new epidemic led to the vulgarization of a set of news about the nature of the virus and the useful treatments to cure it. Meanwhile, the digital media has accelerated the speed at which these news spread, and fake accounts have contributed to their belief, making their risks a new problem on top of the epidemic's problems, and making it difficult for governments and health organizations to control the spread of the epidemic. During such pandemic, it is important to avoid mistakes when communicating on social media, sharing unreliable and incorrect information, ignoring rumors or myths, unrealistic predictions, inaccurate scientific terminology and negative statements. This fake news can have serious consequences for public health and safety. It is therefore important to develop appropriate strategies to deal with these situations, which may vary from region to region. Strategies such as awareness campaigns and promotion of fact checking are examples. In the future, this research could be expanded to include other types of fake news, or use other methods to analyze the strategies.

Data Available

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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