Fuzzy VIKOR Approach: Evaluation of Internet Based Coronavirus Disease (COVID-19) Information

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***Abstract*—Nowadays, the world continues fighting a novel Coronavirus disease, referred to as extreme acute respiratory syndrome Coronavirus two (SARSCoV-2) or (COVID-19), which has contaminated nineteen of millions and killed more than 727,250 people given that the end July of 2020. In Saudi Arabia, COVID-19 has infected two hundreds of thousands and killed more than 3,150 people due to the fact the end July of 2020. However, the satisfactory of the information is questionable. It will be getting worse if solicited records goes wrong, then it tends to have poor consequences on the general public. Assessing the quality of internet COVID-19 information is generally difficult but a rational and systematic strategy can be beneficial in evaluating the quality of the information they provide to public. The purpose of this study is to evaluate the quality of online COVID-19 information in Saudi Arabia by using fuzzy VIKOR approach, one of multi-criteria decision making (MCDM) techniques in fuzzy environment. This study benefits COVID-19 patients recognize that Ministry of Health (MOH) websites have the mandate and the competence to educate the public on COVID-19 issues. Besides, it helps them in their unravel to ensure the high-quality of COVID-19 information on the internet.**

Keywords-coronavirus (COVID-19); fuzzy VIKOR approach; Multi-Criteria Decision Making (MCDM); ministry of health (MOH); online information quality

I. INTRODUCTION

Internet has emerge as a dominant world information source. Health information that was once before the extraordinary preserve of medical professionals is becoming freely accessible. Nowadays, with high-speed broadband, smart mobile devices and wireless networks, public has grew to become to the Internet for health information. Although most of the on line health information comes from authoritative sources such as research institutions, governmental agencies, medical centers, product vendors and individual professionals, but many of them additionally originate from sources who even though good-intentioned, tends to deceive and deceive users [1]. Thus, this situation breeds distrust and provides issues of credibility involving the source or the websites from which information is sought. Moreover, searching for quality health information on the Internet can be difficult due to the fact of the speed and lack of manipulate with which the information is accumulating.

Numerous research had been accomplished in assessing the quality of online health information. Most of them came out with the assessment criteria and frameworks for evaluating the quality of online fitness information [2–6]. Afful-Dadzie et al. [1, 7] proposed a framework the utilization of fuzzy VIKOR technique and used it to consider domain-specific online health information (diabetes and HIV) in Swazila. However, to the excellent of our knowledge, there is no evaluation have been performed on the quality of on line COVID-19 information specially in Saudi Arabia.

Coronavirus disease regarded in the medical field as (COVID-19) has a disastrous have an impact on international health around the world. The extreme cases of infected human beings are suffering from acute coronavirus respiratory syndrome regarded as (SARS-CoV-2). The most important action has been taken to beat the COVID-19, is primarily based totally on handing over the intensive care to patient's that acquired a nice screening prognosis of COVID-19 [8]. Providing them with the proper treatments and mitigating the side effect as plenty as possible. Keeping the doubtlessly contaminated human beings away from different human beings to stop spread and transmit the virus [8].

Medical professionals dealing with a massive challenge when making decisions of the utilization of the computer-decision support system [9], [10] to grant a dependable solution which helps them inspect a specific state-of-the-art disorder such as COVID-19 [11]. In the meantime, the COVID-19 pandemic is a life threatening disease, its impact leads to death and it threatens the world health around the world.

MOH in Saudi Arabia launches a numerous e-Platform for Health Awareness as:

A. "Live Well"

App aims to make this account the principle reference for dependable health information. The "Live Well" page will provide primary and numerous health information about the health of all strata of society, from childhood to old age [12].

B. "Tabaud"

App is one of technical answers, evolved to music Coronavirus spread. The App allows its users to recognise if they had contact with humans showed to be inflamed with

Coronavirus. additionally, it sends proactive notifications to users, if any showed cases is detected via the App. for the duration of the beyond fourteen days, even as maintaining statistics confidentiality [13].

C. "Tawakkalna"

App is developed in advanced to reveal the health status of its users via coloured codes at the very best diploma of safety and privacy. The App additionally lets in people to make contributions to breaking the chain of infection by way of reporting infected cases or gatherings that violate the followed precautionary measures [13].

D. "Tatamman"

App. reinforces the dedication of all men and women directed to isolation, and observe-up their cases; in an endeavor to open a direct communique channel, as a part of the efforts of various authorities which have made human health at the leading edge of their concerns and priorities. offerings furnished within the utility: (1) COVID-19 take a look at outcomes, (2) Direct touch with 937-provider center to invite for help, (three) daily signs check-up, (4) replace the information of close contacts to COVID-19 instances, (5) educational content material library, and (6) Countdown indicator for isolation days [13].

E. "Seha"

E-Health App. affords modern and sustainable answers to permit people to get hold of fitness and preventive care at their homes and to revel in a higher health services through audio-video medical consultations by MOH's specialists, and via artificial intelligence technologies, which enable you to receive safe medical facts and offer you with fitness guidelines electronically [13].

F. "Ashanak"

App gives several offerings to MOH's staffs, along with promotions, registration in journeys, in addition to comply with-up of sports, events and registration in them. The App also offers (UR worth) offerings to proportion the events of MOH's group of workers-which includes having new infant - congratulate them and provide presents. The App additionally advertises MOH's mandate jobs, circulars, therefore, enabling all workforce to results easily view them. in addition, the App publishes a monthly on line mag name (Wareed)-vein. The App additionally seeks to decorate the pride of MOH's personnel and enhance their professional loyalty [13].

G. "Mawid"

App permits sufferers to book their appointments in primary healthcare centers in coordination with the involved branch. subsequently, sufferers can book, amend or cancel their appointments at any hospital wherein they were referred through a unbroken channel presented through this App [13].

H. "Mawared"

App is designed to provide legitimate self-services to MOH's staff. The App serves because the single legitimate channel to use for all sorts of leaves, inclusive of annual, sick and informal. via this App., MOH's staff might be capable of publish their programs for office resumption, assignments...etc [13].

The objective of this study is to evaluate the quality of online COVID-19 information in Saudi Arabia that posted by MOH websites using fuzzy VIKOR approach, that considered as a one of multi-criteria decision making (MCDM) techniques in fuzzy environment.

II. FUZZY MCDM

Multi-Criteria Decision Making (MCDM) as a methodological and modeling tool is used to deal with complicated decision making problems. MCDM has over the years come to be one of the most general branches of decision making [14], [15] utilized in many disciplines. Fuzzy logic has validated to be a beneficial and environment friendly way in approaching MCDM in situations of imprecise or subjective data in our natural language expression of thoughts and judgments. Many extended applications and theories have been carried out to address various forms of MCDM since Bellman and Zadeh [16] proposed choice making in fuzzy environment, Fuzzy logic has been extended to almost all MCDM techniques such as VIsekriterijumska optimizacija I KOmpromisno Resenje (VIKOR), Weighted Product Model, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA), Analytic Network Process (ANP), Elimination and Choice Expressing Reality (ELECTRE), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) and Analytic Hierarchy Process (AHP).

III. FUZZY VIKOR METHOD

VIKOR is a compromise ranking method introduced by Opricovic [17]. The VIKOR technique first establishes (1) a compromise ranking-list, (2) a compromise solution, and (3) the weight steadiness intervals for the compromise solution [17, 18]. It then determines the positive-ideal solution and the negative-ideal solution to useful resource in ranking and choice [19]. The underlying principle of the VIKOR MCDM technique is to deal with rating and selection of alternatives which have multi-conflicting or non-commensurable standards [20]. As is frequent of most MCDM techniques, the VIKOR method used to be additionally extended to accommodate subjectivity and imprecise data beneath fuzzy environment [21].

A wide variety of functions from a range of disciplines have been carried out the usage of the fuzzy VIKOR method. In [22], fuzzy VIKOR is used in deciding on insurance plan corporations in a crew selection making process whiles [23] employed fuzzy VIKOR to resolve multi-criteria decision making problems. The approach is used by [24, 25] for supplier selection problems. In [25], however, the approach is modified the utilization of entropy measure for goal weighting. In [26] fuzzy VIKOR is utilized for optimized partners' desire in IS/IT outsourcing projects. In [27] the compromise approach is used to choose renewable power project in Spain. In [28] a blended form of fuzzy VIKOR and GRA methods is utilized to consider provider quality of airports, [27] utilized fuzzy VIKOR for material selection and [30] used fuzzy VIKOR in a robotic selection.

Again in [31], fuzzy VIKOR primarily based absolutely on DEMATEL and ANP is utilized in assessing information security hazard control. The literature reviewed portrays the underlying principle of the VIKOR technique for choosing and rating problems however seldom utilized in evaluation of service quality.

IV. FUZZY VIKOR FRAMEWORK

Fuzzy VIKOR approach used in this study is organized in the following order. First, the criteria, alternatives and a crew of decision makers are selected. Second, the linguistic time period sets are recognized for weights and ratings. Third, the individual linguistic preferences for standards and options are collected and changed into weights and decision matrix. Fourth, the weights and decision matrix are defuzzified into crisp weights and ratings. Fifth, the excellent and worst values are calculated in order to compute Si, Ri, and Qi index values. Lastly, the alternatives are ranked and for this purpose a compromise solution is proposed. The small print of the framework with specific equations that are used in this study can be decided in [32].

V. RESULT AND DISCUSSION

This section demonstrates how the fuzzy VIKOR method can be used to evaluate and rank online COVID-19 information providers in Saudi Arabia by the Ministry of Health (MOH).

First, the criteria, alternatives and a group of decision makers were selected. Fifteen criteria that have been proposed with the aid of Afful-Dadzie et al. [1] were adopted in this study (refer to Fig. 1). The criteria were grouped into five predominant clusters, credibility, content, design, and security. A group of four decision makers consist of COVID-19 specialist, medical practitioner, information security expert and web designer were selected to consider the quality of the online COVID-19 information providers by MOH websites. Alexa to be used in searching for the COVID-19 information over MOH online platforms. The keyword 'COVID-19 in Saudi Arabia' was entered and 498,000,000 results were displayed. All links to research papers and news were omitted. Links to information on COVID-19 and any association in Saudi Arabia were considered. Only websites that provided English language were selected.

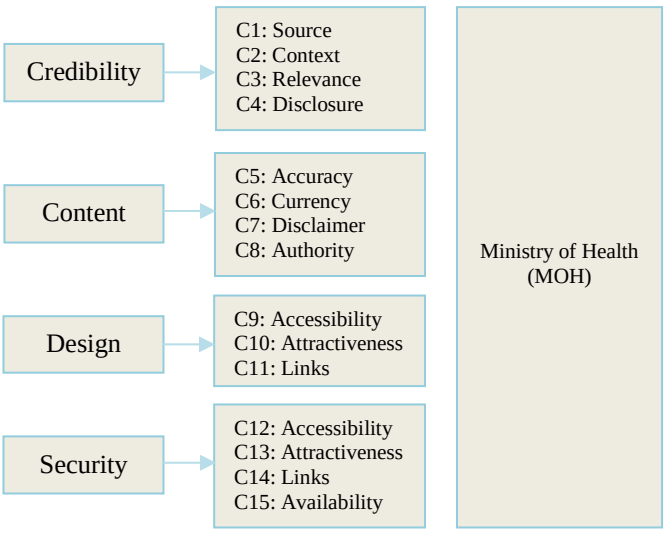

Figure 1. A framework for evaluating quality of internet COVID-19 information.

Second, the linguistic term sets were identified for weights (L_1) and ratings (L_2) as follows:

- L_1 ={VeyHigh(VH) = (0.7,0.9,1.0), High(H) = (0.5,0.7,0.9), Medium(M) = (0.3, 0.5,0.7), Low(L) = (0.1,0.3,0.5), VeryLow(VL) = (0.0,0.1,0.3) },
- L_2 = {Excellent(E) = (0.8,1.0,1.0), VeryGood(VG) = (0.6,0.8,1.0), Good(G) = (0.4,0.6,0.8), Fair(F) = (0.2,0.4,0.6), Poor(P) = (0.0,0.2,0.4), VeryPoor(VP) = (0.0,0.0,0.2)}.

Third, the individual linguistic preferences for criteria have been collected. Table I indicates the evaluation of weight for every criterion. The method used to be repeated for the evaluation of alternatives. The linguistic preferences have been then transformed into triangular fuzzy numbers for weights and alternatives with the aid of using L_1 and L_2 respectively. Then, the fuzzy weights for every criterion and the fuzzy ranking for every alternative had been aggregated via the use of Equations. 5 and 6 in [32] respectively. Table II indicates the aggregated fuzzy decision matrix.

TABLE I. WEIGHT FOR EACH CRITERION

	Weight for each criterion														
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
MOH	VH	VH	VH	H	VH	M	H	H	H	VH	VH	H	VH	VH	VH

TABLE II. AGGREGATED FUZZY DECISION MATRIX

	Aggregated fuzzy decision matrix
	MOH
C1	(0.70,0.90,1.00)
C2	(0.70,0.90,1.00)
C3	(0.70,0.90,1.00)
C4	(0.50,0.70,0.90)
C5	(0.70,0.90,1.00)
C6	(0.30, 0.50,0.70)
C7	(0.50,0.70,0.90)
C8	(0.50,0.70,0.90)
C9	(0.50,0.70,0.90)
C10	(0.70,0.90,1.00)
C11	(0.70,0.90,1.00)

	Aggregated fuzzy decision matrix
	MOH
C12	(0.50,0.70,0.90)
C13	(0.70,0.90,1.00)
C14	(0.70,0.90,1.00)
C15	(0.70,0.90,1.00)

Fourth, the weights and ratings matrix were defuzzified into crisp weights and ratings by using centroid method according to Equation. 7 in [32]. The results are shown in Table III.

TABLE III. CRISP VALUES FOR DECISION MATRIX AND EACH CRITERION WEIGHT

	Crisp values for decision matrix and each criterion weight														
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Weight	0.99	0.99	0.99	0.85	0.99	0.69	0.85	0.85	0.85	0.99	0.99	0.85	0.99	0.99	0.99
MOH	0.90	0.90	0.90	0.70	0.90	0.50	0.70	0.70	0.70	0.90	0.90	0.70	0.90	0.90	0.90

Finally, the best and worst values for each criterion were calculated by using Equations. 8 and 9 in [18] respectively. Table IV shows the best and worst values for each criterion. They were used in calculating the S, R and Q index values for each alternative by using Equations. 10, 11 and 12 in [32] respectively. The results are shown in Table V. The results show that the ranking orders are the same for all index values. It can be clearly seen that Ministry of Health (MOH) has the best quality in terms of provision of online COVID-19 information in Saudi Arabia.

TABLE IV. BEST AND WORST VALUES FOR EACH CRITERION

	Best and worst values for each criterion														
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
$fj^{\sim *}$	0.99	0.99	0.99	0.85	0.99	0.69	0.85	0.85	0.85	0.99	0.99	0.85	0.99	0.99	0.99
$fj^{\sim -}$	0.90	0.90	0.90	0.70	0.90	0.50	0.70	0.70	0.70	0.90	0.90	0.70	0.90	0.90	0.90

TABLE V. S, R AND Q INDEX VALUES FOR EACH ALTERNATIVE

	S, R and Q index values for each alternative
	MOH
S	2.80
R	0.90
Q	0.50

VI. CONCLUSION

In this paper, a fuzzy VIKOR framework has been adopted in ranking and evaluating the online COVID-19 information in Saudi Arabia where linguistic variables are applied to solve the uncertainties and subjectivities in expert decision making.

This study benefits COVID-19 patients know that MOH websites have the mandate and the competence to educate the public on COVID-19 issues. Besides, it helps them in their resolve to ensure the first-rate of COVID-19 information on the internet. Furthermore, it will guide the online information providers in developing a good quality online health information.

For future work, we are going to apply other MCDM methods and do the comparative analysis with the current technique to see which method are better in solving the uncertainties and subjectivities in expert decision making.

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