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Identifying the most critical side effects of antidepressant drugs: a new model proposal with quantum spherical fuzzy M-SWARA and DEMATEL techniques

Gökhan Silahtaroğlu¹, Hasan Dinçer¹, Serhat Yüksel¹, Abdurrahman Keskin^{2*}, Nevin Yılmaztürk² and Alperen Kılıç³

Abstract

Identifying and managing the most critical side effects encourages patients to take medications regularly and adhere to the course of treatment. Therefore, priority should be given to the more important ones, among these side effects. However, the number of studies that make a priority examination is limited. There is a need for a new study that determines which of these effects are more priority to increase the quality of the treatment. Accordingly, this study aims to define the most important side effects of antidepressant drugs with a novel model. Quantum Spherical fuzzy M-SWARA technique is considered to compute the importance weights of the items. The main contribution of this study is that the most critical side effects can be understood for antidepressant drugs by establishing a novel decision-making model. The findings demonstrate that psychological side effects are defined as the most critical side effects of antidepressant drugs. Furthermore, physical side effects also play a key role in this condition. Side effects in antidepressant treatment have a great impact on the effectiveness of treatment and patient compliance.

Keywords Antidepressant drugs, Correct drug use, Side effect, Fuzzy logic, Multi-criteria decision making

Introduction

Doctors should determine the appropriate drugs for their patients. The main reason is that choosing the right medication can have a critical impact on improving patients' health or relieving symptoms. Each disease has different treatment methods and drugs. Doctors can determine the most effective treatment based on the patient's specific

conditions and diagnosis [1]. Incorrect drug selection can lead to delays or failures in disease control or recovery. On the other hand, it is also critical that drugs must be safe as well as effective. Each patient has a different medical history, allergies, or tolerance levels to other medications [2]. By considering patients' current conditions and characteristics, physicians can determine the options that minimize potential side effects. With the help of this issue, these drugs can be the safest for patients. It is very important to identify and reduce the side effects of drugs in this process. Side effects can affect patients' daily lives and may adversely affect the functionality and general quality of life of patients. Identifying and reducing side effects can help patients feel more comfortable during the treatment process and continue their normal lives [3]. Using a drug with adverse side effects may cause patients

*Correspondence:

Abdurrahman Keskin
abdurrahman.keskin@pusulayazilim.com.tr

¹ The School of Business, Istanbul Medipol University, Istanbul, Turkey

² Research and Development Centre, Pusula Enterprise Business Solutions, Istanbul, Turkey

³ Department of Psychiatry, Istanbul University-Cerrahpasa Faculty of Medicine, Istanbul, Turkey



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to hesitate to take the drug or not complete the treatment. Therefore, reducing side effects may encourage patients to be more compliant with medication. Moreover, side effects can sometimes lead to serious health problems [4].

Psychiatric medications can also have some side effects. The side effects of these drugs can vary depending on the type of drug, dose, and individual factors. For example, some antidepressants can have side effects, such as nausea and diarrhea. Similarly, some of these drugs can also cause sexual dysfunction. Furthermore, it is seen that some people who use psychiatric drugs have an excessive need for sleep [5]. On the other hand, the side effects of psychiatric drugs can sometimes lead to serious health problems [6], such as metabolic syndrome, diabetes, and heart problems. Physicians need to take appropriate precautions to manage or minimize these side effects. It is vital to determine the side effects of psychiatric drugs and to take the necessary precautions [7]. This is necessary for the treatment process of patients to be safe and effective. Most of the scholars in the literature examine the possible side effects of psychiatric drugs [8]. However, there are limited studies on which side effects are more important. On the other hand, it is critical to determine the most critical side effects of psychiatric drugs [9]. Long-term treatments are common, especially with psychological side effects. Thus, identifying and managing the most critical side effects encourages patients to take medications regularly and adhere to the course of treatment. This situation increases treatment compliance and may positively affect treatment outcomes [10]. Therefore, priority should be given to the more important ones, among these side effects. Nevertheless, the number of studies that make a priority examination is limited. This situation can be accepted as an essential gap in this literature. As a result, there is a need for a new study that determines which of these effects are more priority to increase the quality of the treatment [11].

Accordingly, this study, aims to determine the most important side effects of antidepressant drugs. The research question of the study is which side effects should doctors primarily consider when administering antidepressant medications to their patients. In this context, a comprehensive literature review has been carried out and basically, six different side effects of these drug types are determined. After that, a novel model is suggested to determine which side effects are more important. In this model, the quantum spherical fuzzy M-SWARA technique is taken into consideration to calculate the importance weights of the criteria. On the other hand, a comparative analysis is carried out with the quantum spherical fuzzy DEMATEL method to test the consistency of the results obtained. The main motivation of this

study is the necessity to make a comprehensive evaluation with respect to the side effects of antidepressant drugs. In this framework, decision-making models can be taken into consideration. However, there are lots of criticisms of the existing models. One of the most critical criticisms is related to the failure to successfully manage uncertainty. This condition should be considered while generating a model.

The main contribution of this study is that the most critical side effects can be understood for antidepressant drugs by establishing a novel decision-making model. Thus, it can be possible to mention both theoretical and methodological contributions to the literature. According to the methodological contribution, one of the most important features of the study is the priority analysis to determine the most important side effects of antidepressant drugs. Detecting critical side effects of psychiatric drugs allows for optimizing the treatment plan. Each patient has a different side effect tolerance and risk profile. Detection of side effects helps physicians select medications and adjust dosages based on patients' individual characteristics, medical history, and sensitivity to side effects [12]. Thus, it is ensured that patients have the most appropriate treatment plan and achieve the best results by minimizing side effects. On the other side, regarding the methodological contribution, the main superiorities of this proposed model compared with the previously generated ones are demonstrated as follows. (i) The main methodological novelty of this study is the generation of a new decision-making technique named M-SWARA. Although the classical SWARA approach provides many benefits, the causal relationship between the items cannot be considered [13]. However, the side effects of psychiatric drugs may have a strong influence on each other. For instance, psychological side effects can also increase the problems related to the stomach. The causal directions between the indicators cannot be identified by other weighting models in the literature, such as the analytical hierarchy process and analytical network process. Owing to this situation, some improvements are made to the classical SWARA technique, and M-SWARA methodology is proposed. This newly developed technique helps to consider the cause-and-effect relationship between the criteria [14]. (ii) The use of the DEMATEL technique in the evaluation of the criteria provides some advantages. The side effects of psychiatric drugs can be effective on each other. For example, stomach side effects can have an effect on physical side effects. Many different decision-making techniques are used in literature. The most important advantage of the DEMATEL method over the others is that it also examines the cause-effect relationship between the criteria [15, 16]. Therefore, it is seen that the DEMATEL technique is the most optimal

method in the analysis to be made to determine the most significant side effect. In addition to this situation, the DEMATEL methodology is also used in this proposed model to check the reliability of the findings. In other words, in this study, two different methods are taken into consideration for weighting the criteria. Thus, it becomes possible to make a comparative analysis. This helps to test the accuracy, consistency, and reliability of the results obtained. In this way, more effective strategies can be developed. (iii) Integrating quantum theory and spherical fuzzy numbers also provides some advantages. Quantum theory allows to consider different possibilities [17]. This theory is very successful in making accurate estimations. Due to this benefit, quantum theory is used with fuzzy decision-making methodology. Hence, uncertainties in the analysis process can be handled more successfully. On the other hand, Spherical fuzzy sets use a three-dimensional membership function, namely degree of membership, degree of non-membership, and degree of hesitation. Therefore, these numbers also help to work with a larger data set [18]. Moreover, in spherical fuzzy sets, the degree of hesitation is considered when deciding on the membership of an element. Thanks to this, decision-makers can make a more comprehensive evaluation. This situation can be accepted as the main superiority of these sets over Pythagorean and intuitionistic fuzzy numbers. This issue also contributes to minimizing the uncertainty in the process and achieving more accurate results [19].

A literature review is presented in the second part. The methodology is explained in the new part. The results and conclusions are given in the following sections.

Literature review

Selective serotonin reuptake inhibitors (SSRIs) are the first-line drugs for the treatment of depression [20]. In this drug group, fluoxetine, escitalopram, citalopram, paroxetine, and sertraline are among the most preferred drugs [21]. The most common side effects of antidepressant drugs are sleep, eating, pain, and sexual problems [22]. A study of SSRI drugs focused on the digestive side effects they cause in patients [23]. It has been shown to have side effects such as stomach upset, burning sensation, nausea, vomiting, abdominal pain, diarrhea, and constipation [24].

It is anticipated that the use of SSRIs may worsen depression and sleep-related respiratory disorders, particularly during NREM sleep [25]. In a retrospective study on individuals with depressive disorders and sleep complaints, norepinephrine-dopamine reuptake inhibitors in NREM sleep were found to have a lower oxygen saturation subpoint and a higher oxygen desaturation index than the drug-free group [26]. As a

result, it is predicted that there may be a relationship between irregular breathing problems and nighttime oxygen saturation in patients with depressive disorders and sleep complaints [27]. Psychological symptoms, irritability, anxiety, low mood, sleep disturbance, suicidal thoughts, and hallucinations are observed [28]. The daily side effects in the sample group receiving antidepressant medication were reported as gastrointestinal side effects (17%), indigestion (22%), nausea (18%), diarrhea (9%), and constipation (11%). The side effect reports of the sample group as somatic side effects are fatigue (45%), dizziness (24%), hypotension (15%), headache (34%) and blurred vision (22%). Other reported somatic side effects reports due to hormonal imbalance are as follows: sweating at 34%, sudden heat stroke at 22%, swelling at 8%, and dryness in the mouth at 25% [29, 30]. It is seen that the senses of smell function at a lower level in people treated for depressive disorder compared to control groups [31]. As a result of a systematic literature review that reported sexual disorder, weight changes, and insomnia side effects; In antidepressant drugs such as trazodone, venlafaxine, escitalopram and vortioxetine, sexual dysfunction was observed to be moderate, and anxiety and weight change were among the side effects seen in a high course [32]. Weight gain is among the common side effects of many antidepressant groups [33]. Bupropion is highly relevant for weight loss [34, 35]. On the contrary, weight loss is observed in the drug Topiramate [36].

Psychological side effects account for approximately 22.8% of the global disease burden [37]. The leading cause of this disability is depression, which has increased significantly in the last 30 years due to population growth and aging (WHO, 2008) [38]. This trend poses a significant challenge for health systems in developed and developing countries in treating patients, optimizing resources, and improving mental health services [39, 40]. It has been observed that there are patients who have different responses to the same treatment during drug treatment [41]. It is known that this situation is caused by clinically significant subgroup diseases and personal conditions of individuals [42]. Three drugs were compared in the field study of monotherapy antidepressants [43]. 90.79% of the participants reported an improvement in their psychological distress levels [44]. The results of the drug's efficacy were found to be statistically insignificant, as it was shown to be effective in adult patients suffering from major depressive disorders without accompanying disorders [45]. The future of psychiatry is expected to use big data approach techniques integrating electronic

health records, sensor records, and feedback of the patient informed by clinical evaluation [46, 47].

It is possible to underline some critical issues as a result of the literature evaluation. Most of the scholars in the literature examine the possible side effects of psychiatric drugs. However, there are limited studies on which side effects are more important. On the other hand, it is critical to determine the most critical side effects of psychiatric drugs. Therefore, priority should be given to the more important ones, among these side effects. However, the number of studies that make a priority examination is limited. This condition can be accepted as an essential gap in this literature. In other words, there is a need for a new study that determines which of these effects are more priority to increase the quality of the treatment. To satisfy this gap in the literature, a new decision-making model has been established in this study to make a priority analysis of the side effects of the antidepressant drugs.

Methodology

A novel model is suggested to find the most critical side effects of antidepressant drugs. For this purpose, both Quantum Spherical fuzzy M-SWARA and DEMATEL methods are taken into consideration. In this section, these models are explained. The details of the proposed model are illustrated in Fig. 1.

Spherical fuzzy sets

Multi-criteria decision-making models can be used with fuzzy numbers to increase their effectiveness. It is possible to discuss the importance of using fuzzy numbers in these models. Uncertainty is increasing in real-world problems [48]. Using fuzzy numbers with these techniques also allows this uncertainty to be minimized. In this way, it is possible to model complex relationships more successfully [49]. Spherical fuzzy sets are obtained by expanding Pythagorean and intuitionistic fuzzy numbers. In these sets, a three-dimensional membership function is used, including membership degree, non-membership degree, and hesitation degree. This situation provides more information than classical fuzzy sets. In spherical fuzzy sets, the hesitation degree is considered when deciding on the membership of an element [50]. Thanks to this situation, decision-makers can make a more comprehensive evaluation. Furthermore, the sets work with a more comprehensive data set. This situation allows uncertainty to be managed more successfully. This situation increases the accuracy and reliability of the decision-making process.

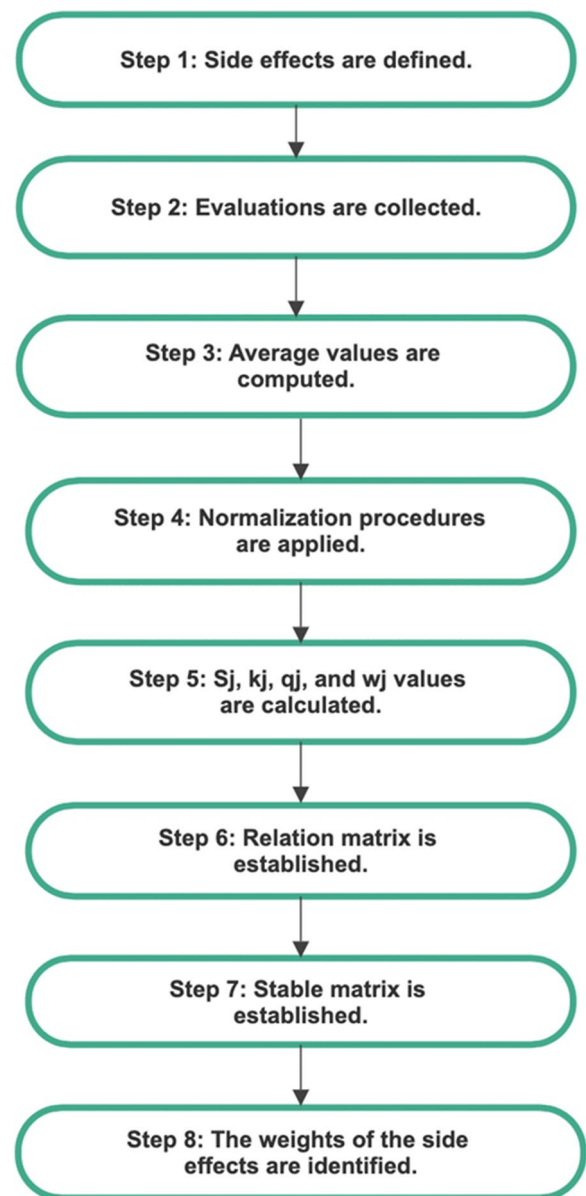


Fig. 1 Flowchart of the proposed model

The extended approach to M-SWARA

SWARA method is used to compute the weights of the items. The main drawback of this technique is that causality evaluation is not identified [51]. To satisfy this situation, some improvements are adopted to SWARA, and a new method (M-SWARA) is generated [52, 53]. With the help of this new approach, an impact relation map of the factors can be created [54]. Firstly, evaluations are taken from the decision-makers. Next, Eq. (1) is used to define the relation matrix.

$$S_k = \begin{bmatrix} 0 & s_{12} & \cdots & \cdots & s_{1n} \\ s_{21} & 0 & \cdots & \cdots & s_{2n} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ s_{n1} & s_{n2} & \cdots & \cdots & 0 \end{bmatrix} \quad (1)$$

In the following process, aggregated values are computed by Eq. (2).

$$s = \left\{ \left[1 - \prod_{i=1}^k (1 - s_{\mu_i}^2)^{\frac{1}{k}} \right]^{\frac{1}{2}} e^{2\pi \cdot \left[1 - \prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} \right]^{\frac{1}{2}}}, \prod_{i=1}^k s_{\nu_i}^{\frac{1}{k}} e^{2\pi \cdot \prod_{i=1}^k \left(\frac{\gamma_i}{2\pi} \right)^{\frac{1}{k}}}, \right. \\ \left. \left[\prod_{i=1}^k (1 - s_{\mu_i}^2)^{\frac{1}{k}} - \prod_{i=1}^k (1 - s_{\mu_i}^2 - s_{h_i}^2)^{\frac{1}{k}} \right]^{\frac{1}{2}} e^{2\pi \cdot \left[\prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} - \prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 - \left(\frac{\beta_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} \right]^{\frac{1}{2}}} \right\} \quad (2)$$

Next, the values are defuzzified with Eq. (3).

$$Def s_i = s_{\mu_i} + \left(\frac{s_{\mu_i}}{s_{\mu_i} + s_{h_i} + s_{\nu_i}} \right) + \left(\frac{\alpha_i}{2\pi} \right) + \left(\frac{\left(\frac{\alpha_i}{2\pi} \right)}{\left(\frac{\alpha_i}{2\pi} \right) + \left(\frac{\gamma_i}{2\pi} \right) + \left(\frac{\beta_i}{2\pi} \right)} \right) \quad (3)$$

After that, s_j (importance rate), k_j (coefficient), q_j (recalculated weight), and w_j (weight) values are calculated by Eqs. (4)-(6).

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \quad (4)$$

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{q_{j-1}}{k_j} & j > 1 \end{cases} \quad (5)$$

sets. After obtaining the evaluations from the expert team, the relation matrix is identified with Eq. (7).

$$S_k = \begin{bmatrix} 0 & s_{12} & \cdots & \cdots & s_{1n} \\ s_{21} & 0 & \cdots & \cdots & s_{2n} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ s_{n1} & s_{n2} & \cdots & \cdots & 0 \end{bmatrix} \quad (7)$$

Equation (8) includes the calculation of the aggregated values.

$$s = \left\{ \left[1 - \prod_{i=1}^k (1 - s_{\mu_i}^2)^{\frac{1}{k}} \right]^{\frac{1}{2}} e^{2\pi \cdot \left[1 - \prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} \right]^{\frac{1}{2}}}, \prod_{i=1}^k s_{\nu_i}^{\frac{1}{k}} e^{2\pi \cdot \prod_{i=1}^k \left(\frac{\gamma_i}{2\pi} \right)^{\frac{1}{k}}}, \right. \\ \left. \left[\prod_{i=1}^k (1 - s_{\mu_i}^2)^{\frac{1}{k}} - \prod_{i=1}^k (1 - s_{\mu_i}^2 - s_{h_i}^2)^{\frac{1}{k}} \right]^{\frac{1}{2}} e^{2\pi \cdot \left[\prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} - \prod_{i=1}^k \left(1 - \left(\frac{\alpha_i}{2\pi} \right)^2 - \left(\frac{\beta_i}{2\pi} \right)^2 \right)^{\frac{1}{k}} \right]^{\frac{1}{2}}} \right\} \quad (8)$$

If $s_{j-1} = s_j$, $q_{j-1} = q_j$; If $s_j = 0$, $k_{j-1} = k_j$

$$w_j = \frac{q_j}{\sum_{k=1}^n q_k} \quad (6)$$

In the final step, weights are calculated while transposing and limiting the matrix to the power of $2t+1$.

Defuzzified values are calculated with Eq. (9).

$$Def s_i = s_{\mu_i} + s_{h_i} \left(\frac{s_{\mu_i}}{s_{\mu_i} + s_{\nu_i}} \right) + \left(\frac{\alpha_i}{2\pi} \right) + \left(\frac{\gamma_i}{2\pi} \right) \left(\frac{\left(\frac{\alpha_i}{2\pi} \right)}{\left(\frac{\alpha_i}{2\pi} \right) + \left(\frac{\beta_i}{2\pi} \right)} \right) \quad (9)$$

Normalization process is applied by Eqs. (10) and (11).

$$B = \frac{\varsigma}{\max_{1 \leq i \leq n} \sum_{j=1}^n \varsigma_{ij}} \quad (10)$$

$$0 \leq b_{ij} \leq 1 \quad (11)$$

Equation (12) is used to create relation matrix.

$$C = \lim_{k \rightarrow \infty} (B + B^2 + \dots + B^k) = B(I - B)^{-1} \quad (12)$$

The sum of rows and columns of this matrix are identified as in Eqs. (13) and (14).

$$D = \left[\sum_{j=1}^n e_{ij} \right]_{n \times 1} \quad (13)$$

$$E = \left[\sum_{i=1}^n e_{ij} \right]_{1 \times n} \quad (14)$$

Finally, causal directions are determined with the threshold value defined in Eq. (15).

$$\alpha = \frac{\sum_{i=1}^n \sum_{j=1}^n [e_{ij}]}{N} \quad (15)$$

An evaluation with fuzzy decision-making models

In this section, the details of the evaluation with Quantum Spherical fuzzy M-SWARA and DEMATEL are presented.

Table 1 Side effects

Side Effects	Supported Literature
Stomach Ailments (STLM)	[2]
Respiratory Ailments (RRLM)	[4]
Psychological side effects (PYDD)	[7]
ENT side effects (ENTD)	[10]
Physical Ailments (PYLM)	[58]
Movement and Support Disorders (MVSD)	[12]

Table 2 Scales

Scales	Possibility Degrees	Numerical Scales	QSFNs
No (n)	0.40	1	$[\sqrt{0.16}e^{j2\pi 0.4}, \sqrt{0.10}e^{j2\pi 0.25}, \sqrt{0.74}e^{j2\pi 0.35}]$
some (s)	0.45	2	$[\sqrt{0.20}e^{j2\pi 0.45}, \sqrt{0.13}e^{j2\pi 0.28}, \sqrt{0.67}e^{j2\pi 0.27}]$
medium (m)	0.50	3	$[\sqrt{0.25}e^{j2\pi 0.50}, \sqrt{0.15}e^{j2\pi 0.31}, \sqrt{0.60}e^{j2\pi 0.19}]$
high (h)	0.55	4	$[\sqrt{0.30}e^{j2\pi 0.55}, \sqrt{0.19}e^{j2\pi 0.34}, \sqrt{0.51}e^{j2\pi 0.11}]$
very high (vh)	0.60	5	$[\sqrt{0.36}e^{j2\pi 0.6}, \sqrt{0.22}e^{j2\pi 0.37}, \sqrt{0.42}e^{j2\pi 0.03}]$

Definition of the problem and identification of criteria set

This study aims to define the most significant side effects of antidepressant drugs. Within this scope, a detailed literature evaluation has been conducted and 6 different side effects of these drug types are selected. The details of the selected side effects of these drugs are denoted in Table 1.

Antidepressant drugs can also cause ear, nose, and throat disorders such as tinnitus and dizziness. These disorders can negatively affect patients' activities of daily living and reduce their general well-being. Some side effects of psychiatric medications can cause physical discomfort. These side effects can manifest as various physical symptoms or disturbances in the body, such as fatigue and headaches. Some side effects of psychiatric drugs can cause movement and balance disorders. These side effects can lead to changes in muscle movements, tremors, or balance problems.

Weighting the factors with quantum spherical fuzzy M-SWARA

Evaluations are obtained from 5 decision makers. These people consider the scales detailed in Table 2.

The details of the evaluations are indicated in Table 3.

In the following step, average values are calculated and given in Table 4.

Relation matrix is constructed with these values as given in Table 8.

Finally, weighting priorities are shown in Table 9.

It is concluded that psychological side effects are defined as the most critical side effects of antidepressant drugs. Similarly, physical ailments also play a key role in this situation. On the other hand, stomach ailments and ENT disorders are in the last ranks.

Making a comparative evaluation with quantum spherical fuzzy DEMATEL

In this section, another evaluation has also been performed by using Quantum Spherical fuzzy DEMATEL methodology. This situation helps to test the quality of

Table 3 Evaluations

	STLM	RRLM	PYDD	ENTD	PYLM	MVSD
Decision Maker 1						
STLM		M	M	S	S	S
RRLM	S		H	M	H	H
PYDD	H	H		H	H	M
ENTD	M	M	H		S	H
PYLM	S	S	H	S		M
MVSD	M	M	VH	N	H	
Decision Maker 2						
STLM		H	H	M	M	M
RRLM	S		H	H	H	H
PYDD	VH	VH		H	H	H
ENTD	S	H	H		M	M
PYLM	M	M	VH	S		H
MVSD	M	M	VH	M	H	
Decision Maker 3						
STLM		S	S	M	S	N
RRLM	S		M	S	H	H
PYDD	VH	H		H	H	H
ENTD	S	M	M		S	M
PYLM	S	M	H	S		VH
MVSD	M	H	H	S	VH	
Decision Maker 4						
STLM		M	H	S	H	M
RRLM	S		M	H	M	M
PYDD	H	M		H	H	M
ENTD	S	M	M		S	S
PYLM	M	M	H	S		H
MVSD	S	H	H	M	H	
Decision Maker 5						
STLM		S	H	S	M	M
RRLM	S		M	S	H	H
PYDD	H	M		M	M	M
ENTD	S	S	S		M	M
PYLM	S	M	H	S		H
MVSD	S	S	H	S	H	

the analysis results. The total relation matrix and weighting priorities are denoted in Table 10.

The comparative weighting priorities computed by both M-SWARA and DEMATEL are illustrated in Fig. 2.

Figure 1 demonstrates that both techniques explain similar issues. This situation gives information that this model provides reliable findings.

Conclusions and discussions

This study aims to define the most essential side effects of antidepressant drugs. For this purpose, a detailed literature review has been carried out and 6 different side

effects of these drug types are identified. In the next process, a novel model is suggested to determine which side effects are more important. In this model, the Quantum Spherical fuzzy M-SWARA technique is taken into consideration to calculate the significance weights of the criteria. Additionally, a comparative analysis is carried out with the Quantum Spherical fuzzy DEMATEL method to test the reliability of the results. It is concluded that psychological side effects are defined as the most critical side effects of antidepressant drugs. Similarly, physical ailments also play a key role in this situation. On the other hand, stomach ailments and ENT disorders are

Table 4 Average values

	STLM	RRLM	PYDD	ENTD	PYLM	MVSD
STLM		$\begin{bmatrix} \sqrt{.24}e^{j2\pi \cdot .48} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .22} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.28}e^{j2\pi \cdot .52} \\ \sqrt{.16}e^{j2\pi \cdot .32} \\ \sqrt{.58}e^{j2\pi \cdot .19} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.22}e^{j2\pi \cdot .47} \\ \sqrt{.14}e^{j2\pi \cdot .29} \\ \sqrt{.64}e^{j2\pi \cdot .24} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.24}e^{j2\pi \cdot .48} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .22} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.23}e^{j2\pi \cdot .48} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.63}e^{j2\pi \cdot .23} \end{bmatrix}$
RRLM	$\begin{bmatrix} \sqrt{.20}e^{j2\pi \cdot .45} \\ \sqrt{.13}e^{j2\pi \cdot .28} \\ \sqrt{.67}e^{j2\pi \cdot .27} \end{bmatrix}$		$\begin{bmatrix} \sqrt{.27}e^{j2\pi \cdot .51} \\ \sqrt{.15}e^{j2\pi \cdot .31} \\ \sqrt{.60}e^{j2\pi \cdot .22} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.26}e^{j2\pi \cdot .50} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .23} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.29}e^{j2\pi \cdot .54} \\ \sqrt{.18}e^{j2\pi \cdot .33} \\ \sqrt{.54}e^{j2\pi \cdot .15} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.29}e^{j2\pi \cdot .54} \\ \sqrt{.18}e^{j2\pi \cdot .33} \\ \sqrt{.54}e^{j2\pi \cdot .15} \end{bmatrix}$
PYDD	$\begin{bmatrix} \sqrt{.33}e^{j2\pi \cdot .57} \\ \sqrt{.20}e^{j2\pi \cdot .35} \\ \sqrt{.49}e^{j2\pi \cdot .11} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.30}e^{j2\pi \cdot .55} \\ \sqrt{.19}e^{j2\pi \cdot .34} \\ \sqrt{.51}e^{j2\pi \cdot .11} \end{bmatrix}$		$\begin{bmatrix} \sqrt{.29}e^{j2\pi \cdot .54} \\ \sqrt{.18}e^{j2\pi \cdot .33} \\ \sqrt{.54}e^{j2\pi \cdot .15} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.29}e^{j2\pi \cdot .54} \\ \sqrt{.18}e^{j2\pi \cdot .33} \\ \sqrt{.54}e^{j2\pi \cdot .15} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.27}e^{j2\pi \cdot .51} \\ \sqrt{.15}e^{j2\pi \cdot .31} \\ \sqrt{.60}e^{j2\pi \cdot .22} \end{bmatrix}$
ENTD	$\begin{bmatrix} \sqrt{.21}e^{j2\pi \cdot .46} \\ \sqrt{.13}e^{j2\pi \cdot .28} \\ \sqrt{.66}e^{j2\pi \cdot .26} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.25}e^{j2\pi \cdot .50} \\ \sqrt{.15}e^{j2\pi \cdot .31} \\ \sqrt{.60}e^{j2\pi \cdot .19} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.26}e^{j2\pi \cdot .50} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .23} \end{bmatrix}$		$\begin{bmatrix} \sqrt{.22}e^{j2\pi \cdot .47} \\ \sqrt{.14}e^{j2\pi \cdot .29} \\ \sqrt{.64}e^{j2\pi \cdot .24} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.25}e^{j2\pi \cdot .50} \\ \sqrt{.15}e^{j2\pi \cdot .31} \\ \sqrt{.60}e^{j2\pi \cdot .19} \end{bmatrix}$
PYLM	$\begin{bmatrix} \sqrt{.22}e^{j2\pi \cdot .47} \\ \sqrt{.14}e^{j2\pi \cdot .29} \\ \sqrt{.64}e^{j2\pi \cdot .24} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.24}e^{j2\pi \cdot .48} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .22} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.32}e^{j2\pi \cdot .57} \\ \sqrt{.20}e^{j2\pi \cdot .35} \\ \sqrt{.48}e^{j2\pi \cdot .09} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.20}e^{j2\pi \cdot .45} \\ \sqrt{.13}e^{j2\pi \cdot .28} \\ \sqrt{.67}e^{j2\pi \cdot .27} \end{bmatrix}$		$\begin{bmatrix} \sqrt{.31}e^{j2\pi \cdot .55} \\ \sqrt{.19}e^{j2\pi \cdot .34} \\ \sqrt{.51}e^{j2\pi \cdot .13} \end{bmatrix}$
MVSD	$\begin{bmatrix} \sqrt{.23}e^{j2\pi \cdot .48} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.63}e^{j2\pi \cdot .23} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.26}e^{j2\pi \cdot .50} \\ \sqrt{.14}e^{j2\pi \cdot .30} \\ \sqrt{.62}e^{j2\pi \cdot .23} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.33}e^{j2\pi \cdot .57} \\ \sqrt{.20}e^{j2\pi \cdot .35} \\ \sqrt{.49}e^{j2\pi \cdot .11} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.22}e^{j2\pi \cdot .47} \\ \sqrt{.14}e^{j2\pi \cdot .29} \\ \sqrt{.64}e^{j2\pi \cdot .24} \end{bmatrix}$	$\begin{bmatrix} \sqrt{.32}e^{j2\pi \cdot .57} \\ \sqrt{.20}e^{j2\pi \cdot .35} \\ \sqrt{.48}e^{j2\pi \cdot .09} \end{bmatrix}$	

Table 8 Relation matrix

	STLM	RRLM	PYDD	ENTD	PYLM	MVSD
STLM		0.211	0.253	0.149	0.211	0.177
RRLM	0.144		0.202	0.169	0.243	0.243
PYDD	0.238	0.198		0.198	0.198	0.167
ENTD	0.149	0.210	0.254		0.177	0.210
PYLM	0.162	0.192	0.280	0.138		0.228
MVSD	0.162	0.191	0.280	0.138	0.229	

Table 9 Stable matrix and weighting priorities

	STLM	RRLM	PYDD	ENTD	PYLM	MVSD	Weighting priorities
STLM	0.149	0.149	0.149	0.149	0.149	0.149	5
RRLM	0.166	0.166	0.166	0.166	0.166	0.166	4
PYDD	0.203	0.202	0.203	0.203	0.203	0.203	1
ENTD	0.138	0.138	0.138	0.138	0.138	0.138	6
PYLM	0.175	0.175	0.175	0.175	0.175	0.175	2
MVSD	0.169	0.169	0.169	0.169	0.169	0.169	3

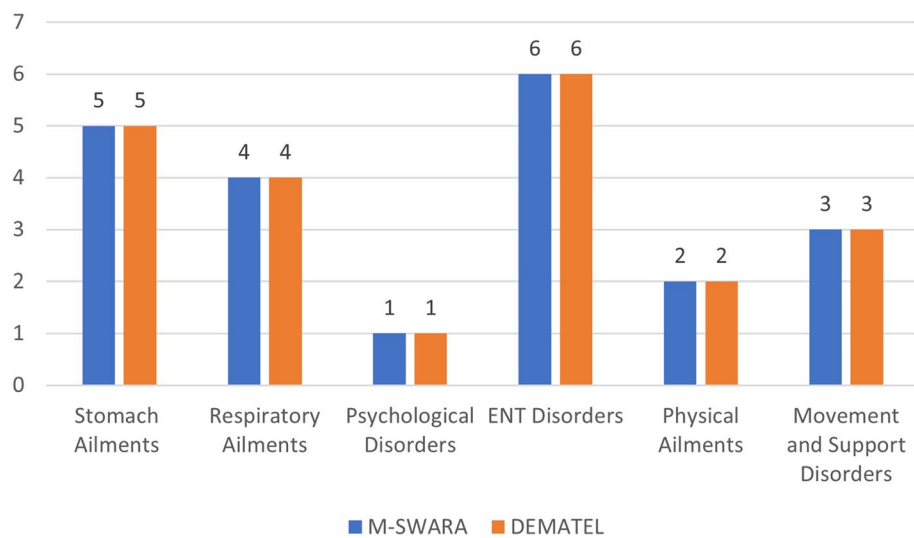
on the last ranks. Similarly, the core symptoms of psychiatric disorders are psychological and physical, which are an important part of them. For this reason, this modeling may provide some solution to the dilemma of whether these are the symptoms of psychiatric disorders or the side effects of antidepressant drugs, which are perhaps

the most difficult things for physicians in the drug treatment process.

Antidepressant drugs have become very widely prescribed. Along with the high level of effectiveness of drugs, their side effects are also quite common. This often leads to discontinuation of treatment [59]. Side

Table 10 Total relation matrix and weighting results

	STLM	RRLM	PYDD	ENTD	PYLM	MVSD	D	E	D + E	D - E	Weighting results	Weighting priorities
STLM	1.641	1.864	1.988	1.774	1.919	1.896	11.08	11.03	22.11	0.049	0.159	5
RRLM	1.858	1.800	2.079	1.866	2.024	2.007	11.63	11.53	23.17	0.103	0.167	4
PYDD	2.014	2.087	2.048	1.994	2.148	2.123	12.41	12.29	24.71	0.119	0.178	1
ENTD	1.778	1.865	1.982	1.630	1.910	1.904	11.07	10.97	22.04	0.095	0.159	6
PYLM	1.846	1.929	2.071	1.829	1.838	1.990	11.50	11.90	23.40	-0.394	0.168	3
MVSD	1.896	1.985	2.127	1.880	2.061	1.871	11.82	11.79	23.61	0.028	0.170	2


Fig. 2 Comparative Weighting Results

effects in antidepressant treatment have a great impact on the effectiveness of treatment and patient compliance. The treatment is started by choosing among the drugs that are thought to be effective in the decision-making phase of the treatment by the physician. Due to the individual situation and adverse effects, it is possible to change the medication during the treatment period. The side effects may prevent the person from losing faith in treatment and trying a new drug. The clinical decision support system, which takes into consideration the personal differences of the patients, recommends the drugs that are expected to have the least side effects at this stage. The system should be designed as supportive for the physician to give the right treatment at the right time. Otherwise, the treatment process of the patients can be significantly prolonged. This situation causes a significant deterioration in the quality of life of patients. One of the most important contributions of the study is making a priority analysis to determine the most important side effects of antidepressant drugs. Detection of side effects helps physicians select medications and adjust dosages based on patients' individual characteristics, medical

history, and sensitivity to side effects. This situation helps patients have the most appropriate treatment plan and achieve the best results by minimizing side effects. Side effect studies are generally performed in single drug use and homogeneous patient groups. In the study, the patients in the sample group whose side effect reports were collected include a sample group suitable for real-life use, who also use drugs other than antidepressants due to different types of diseases. In this respect, it stands out differently from similar studies that include a single drug and a homogeneous sample population.

The main contribution of this study is that the most critical side effects can be understood for antidepressant drugs by establishing a novel decision-making model. Additionally, the generation of a new decision-making technique named M-SWARA is also accepted as the main methodological originality of this study. This newly developed technique helps to consider the cause-and-effect relationship between the criteria. Integrating quantum theory and spherical fuzzy numbers also provides some advantages. Quantum theory allows us to consider different possibilities. This theory is very successful in making

accurate estimations. Due to this benefit, quantum theory is used with fuzzy decision-making methodology. Hence, uncertainties in the analysis process can be handled more successfully. This study has many limitations, both theoretically and methodologically. In terms of methodological limitations, only antidepressant drugs are included in the scope of the study. However, side effects are also very important for other types of drugs. In this context, other types such as stomach drugs can be examined in future studies. On the other hand, there are some limitations in the model developed in this study. In this model, 3 different experts are asked to evaluate the criteria. The average of the evaluations obtained in this process is taken. In other words, the importance and weight of each expert is accepted as equal. However, this situation is also criticized by many researchers. The reason for this is that each of the experts has different educational backgrounds and work experiences. In this direction, a model can be established in future studies in which the importance weights of the experts are determined. Techniques such as artificial intelligence and machine learning can contribute significantly to achieving this goal.

Authors' contributions

All authors contributed equally to the work. G.S, H.D, S.Y, A.K, N.Y, A.K, jointly carried out the design, methodology, data analysis and interpretation of the results of the study. All authors reviewed and approved the manuscript.

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Availability of data and materials

Data Availability Statement: "This study did not involve the use of datasets that require a Data Availability Statement. "Additional Explanation: "Although the 'Yes' option was selected in the system, this study does not involve any datasets that require a data availability statement. The statement provided above reflects the accurate status regarding data availability."

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

The authors declare no competing interests.

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