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A Mathematical Analysis of the Relationship Between the Vaccination Rate And COVID-19 Pandemic in Turkey

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R E S E A R C H A R T I C L E

A B S T R A C T

One of the most important uncertainty problems encountered today is how to take action against the Covid-19 pandemic. The most important of these measures is undoubtedly vaccination. In this study, vaccination process implemented in Turkey Covidien-19 was analysed. Intuitionistic fuzzy soft sets, which is an important mathematical model developed for uncertainty, were used for this analysis process. In addition, an algorithm has been proposed to better evaluate the obtained findings. As a result, with the increase in vaccinations, the number of people caught in the pandemic has decreased.

1. Introduction

It has become a very important issue to be able to express the uncertainty problems in the most accurate way and thus to obtain the solution of the problem in a way that is close to the ideal. It is a very difficult task to accurately express the uncertainty problems encountered in fields such as engineering, education, health, where the human factor is felt today. One of the most important reasons for this difficulty is the possibility that the human factor may depend on many parameters. For this reason, many researchers have brought many mathematical models to the literature. The first of these mathematical models is the fuzzy set theory proposed by Zadeh in 1965 [1]. According to this theory, the belonging of an element to the set is expressed with the help of its membership degree. Then, intuitionistic fuzzy set theory, which is a generalization of fuzzy sets, was given by Atanassov [3]. Intuitionistic fuzzy sets make use of two different pairings, membership degree and non-membership degree, respectively, in expressing the belonging and non-belonging of an element to the set. In this case, we can say that the intuitionistic fuzzy set theory is a more successful mathematical approach than fuzzy sets in expressing the current uncertainty situation. Although the fuzzy set theory and its generalizations, which were put forward to overcome uncertainty, are very successful mathematical models, they have some difficulties in expressing the existing uncertainty. The reason for these difficulties is the lack of a parameterization tool; Molodsov introduced soft sets to the literature in 1999 [4]. Soft set

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theory focuses on the current universe set and expresses the set of objects corresponding to each parameter in the parameter set. Thanks to this advantage, a lot of work has been done on soft sets in many fields [9-13].

Many hybrid set types have been brought to the literature by transferring the parameterization tool in soft set theory to many different set types [14-20]. One of these hybrid set types, the intuitionistic fuzzy soft set theory Maji et al. suggested by [5]. A special form of these sets is Borah et al. They constructed by expressing the membership degree, non-membership degree and uncertainty degree of each parameter about the object [6]. In this way, it was possible to carry out the calculations in the problems related to uncertainty in a practical way.

A new human coronavirus, SARS-CoV-2, first emerged as a severe respiratory infection in December 2019 in Wuhan, one of China's industrial cities. SARS-CoV-2 infection and the following Coronavirus 2019 disease (Covid-19) rapidly spread all over the world, and for this reason, it was declared a pandemic by the World Health Organization on March 11, 2020 [8]. Many studies have been carried out to prevent further spread of this pandemic and on which parameters it depends. [20-26]. In this study, it will be analysed whether the vaccinations applied in Turkey have a positive or negative effect despite the Covid-19 pandemic. In addition, an algorithm is proposed to analyse the relationships between the periods examined in the study.

This study was inspired by a study in India examining the relationship between weather conditions and Covid-19 disease [6]. The aim of this study is to create a mathematical proof of the relationship between the vaccination process and Covid-19 disease based on similar correlation measures.

2. Material and Method

In this section, some necessary reminders are made for a better understanding of the rest of the study. In addition, since the vaccinations were made in two doses, the cases (patient /recovered /deceased) approved via the TR Ministry of Health Covid-19 Information Platform were selected as the dataset for the period of no vaccination, the period between the 1st dose and the 2nd dose, and the period after the 2nd dose. [7]. In order to express the relationships between these periods, the formulas that calculate the correlation coefficients expressed by using intuitionistic fuzzy soft sets were taken as references.

Throughout this study, $\mathrm{U}=\{\mathrm{u}_1,\mathrm{u}_2,\ldots,\mathrm{u}_\mathrm{n}\}$ is an initial universe other than empty, $P(U)$ is expressed as the power set of U, and P is the set of all possible parameters according to the universe U. Moreover, let X and Y be a non-empty subset of P.

The first mathematical model proposed to express uncertainty problems more accurately and to obtain more ideal results in this way is fuzzy set theory, which is expressed as follows by Zadeh [1]:

Definition 2.1. The set $\mathrm{F}=\{(\mathrm{u},\mu_\mathrm{F}(\mathrm{u})):\mathrm{u}\in\mathrm{U}\}$, with $\mu_\mathrm{F}:\mathrm{U}\to[0,1]$ being a function, is called a fuzzy set on U [1]. Here, the value $\mu_\mathrm{F}(\mathrm{u})$ indicates the membership degree of the u element.

Definition 2.2. Suppose a set of paired data corresponding to the membership degrees of fuzzy sets F_1 and F_2 on U are given as follows:

$$\left(\mu_{F_1}(u_1),\mu_{F_2}(u_1)\right),\left(\mu_{F_1}(u_2),\mu_{F_2}(u_2)\right),\ldots,\left(\mu_{F_1}(u_n),\mu_{F_2}(u_n)\right)$$

In this case, the correlation coefficient $K_f(F_1,F_2)$ of F_1 and F_2 is calculated as follows [2]:

$$K_f(F_1,F_2)=\frac{\sum_{i=1}^{n}\left(\mu_{F_1}(u_i)-\overline{\mu_{F_1}}\right)\left(\mu_{F_2}(u_i)-\overline{\mu_{F_2}}\right)}{\left(\sum_{i=1}^{n}\left(\mu_{F_1}(u_i)-\overline{\mu_{F_1}}\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\mu_{F_2}(u_i)-\overline{\mu_{F_2}}\right)^2\right)^{0.5}} \tag{1}$$

Here; $\overline{\mu_{F_1}}=\frac{1}{n}\sum_{i=1}^{n}\mu_{F_1}(u_i)$ and $\overline{\mu_{F_2}}=\frac{1}{n}\sum_{i=1}^{n}\mu_{F_2}(u_i)$.

Atanassov extended fuzzy sets to intuitionistic fuzzy sets [3];

Definition 2.3. An intuitionistic fuzzy set B on U is given as $\mathrm{B}=\{(\mathrm{u},\mu_\mathrm{B}(\mathrm{u}),\upsilon_\mathrm{B}(\mathrm{u})):\mathrm{u}\in\mathrm{U}\}$ [3]. Here; $\mu_\mathrm{B}:U\to[0,1]$ and $\upsilon_\mathrm{B}:U\to[0,1]$ and for each $u\in U$, the condition $0\le\mu_\mathrm{B}(\mathrm{u})+\upsilon_\mathrm{B}(\mathrm{u})\le1$ is fulfilled. Also, the values $\mu_\mathrm{B}(\mathrm{u})$ and $\upsilon_\mathrm{B}(\mathrm{u})$ represent the membership degree and non-membership degree of element u belonging to set B, respectively.

Moreover, every intuitionistic fuzzy set B on U is $\pi_B(u)=1-\mu_\mathrm{B}(\mathrm{u})-\upsilon_\mathrm{B}(\mathrm{u})$ for every $u\in U$ [3]. Here, the value of $\pi_B(u)$ is called the uncertainty degree of u belonging to B.

Moreover, for intuitionistic fuzzy sets B_1 and B_2 on U, the following is implemented [3]:

(i) $B_1 \subset B_2$ if and only if $\mu_{B_1}(u) \leq \mu_{B_2}(u)$ ve $\upsilon_{B_1}(u) \geq \upsilon_{B_2}(u)$ for each $u \in U$.
(ii) $B_1 = B_2$ if and only if $B_1 \subset B_2$ ve $B_2 \subset B_1$.
(iii) $B_1 \cup B_2 = \left\{\left(u, max\left(\mu_{B_1}(u), \mu_{B_2}(u)\right), min\left(\upsilon_{B_1}(u), \upsilon_{B_2}(u)\right)\right): u \in U\right\}$.
(iv) $B_1 \cap B_2 = \left\{\left(u, min\left(\mu_{B_1}(u), \mu_{B_2}(u)\right), max\left(\upsilon_{B_1}(u), \upsilon_{B_2}(u)\right)\right): u \in U\right\}$.

Throughout this study, we will denote the family of all intuitionistic fuzzy sets on U with the symbol $SB(U)$.

Fuzzy sets and its generalizations have presented a very successful approach to expressing uncertainty problems. However, it is a serious problem that the application of the proposed theories to an uncertainty problem is generally a difficult task. In order to overcome this problem; Molodsov brought the soft set theory to the literature [4]. This mathematical model, with the contribution of a parameterization tool, is defined as follows:

Definition 2.4. $F: X \to P(U)$ being a transformation, the pair F_X is called a soft set on U [4].

In this way, different types of hybrid set approaches have been proposed by considering fuzzy sets and intuitionistic fuzzy sets together with soft sets. One of them is Maji et al. are intuitionistic fuzzy soft sets given by [5];

Definition 2.5. The pair Ψ_X, of which $\Psi: X \to SB(U)$ is a transformation, is called an intuitionistic fuzzy soft set on U [5].

In intuitionistic fuzzy soft sets, we can express the membership degree, non-membership degree and uncertainty degree of each parameter about the object [6]. e.g; an intuitionistic fuzzy soft set Ψ_X over U can be expressed as:

$$\Psi_X = \{p_1: \{(u_1, 0.4,0.5,0.1), (u_2, 0.36,0.44,0.2)\}, p_2: \{(u_1, 0.3,0.2,0.5), (u_2, 0.6,0.1,0.3)\}\}$$

Definition 2.6. The correlation coefficient $\breve{K_f}(\Psi_X, \psi_Y)$ between intuitionistic fuzzy soft sets Ψ_X and ψ_Y on U is calculated as follows [6]:

$$\breve{K_f}(\Psi_X, \psi_Y) = \frac{1}{3}\left[K_f^{\mu}(\Psi_X, \psi_Y) + K_f^{\upsilon}(\Psi_X, \psi_Y) + K_f^{\pi}(\Psi_X, \psi_Y)\right]$$

Here;

$$K_f^{\mu}(\Psi_X, \psi_Y) = \frac{\sum_{t=1}^{n}\left\{\left(\mu_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\mu_{p_i(\Psi_X)}(u_t)\right)\left(\mu_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\mu_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\mu_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\mu_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\mu_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\mu_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (2)$$

$$K_f^{\upsilon}(\Psi_X, \psi_Y) = \frac{\sum_{t=1}^{n}\left\{\left(\upsilon_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\upsilon_{p_i(\Psi_X)}(u_t)\right)\left(\upsilon_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\upsilon_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\upsilon_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\upsilon_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\upsilon_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\upsilon_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (3)$$

$$K_f^{\pi}(\Psi_X, \psi_Y) = \frac{\sum_{t=1}^{n}\left\{\left(\pi_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\pi_{p_i(\Psi_X)}(u_t)\right)\left(\pi_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\pi_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\pi_{p_i(\Psi_X)}(u_t) - \frac{1}{m+n}\sum_{t=1}^{n}\pi_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\pi_{p_j(\psi_Y)}(u_t) - \frac{1}{p+n}\sum_{t=1}^{n}\pi_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (4)$$

and $i = 1,2, \dots, m = |X|$, $j = 1,2, \dots, p = |Y|$. Also $|X|$ and $|Y|$ denotes the cardinality of X and Y, respectively.

Properties 2.1. Let Ψ_X ve ψ_Y be two intuitionistic fuzzy soft sets on U. Then the following statements are true [6]:

(i) $\breve{K_f}(\Psi_X, \psi_Y) = \breve{K_f}(\psi_Y, \Psi_X)$.
(ii) If $\Psi_X = \psi_Y$, then $\breve{K_f}(\Psi_X, \psi_Y) = 1$.
(iii) $|\breve{K_f}(\Psi_X, \psi_Y)| \leq 1$.

Definition 2.7. The correlation coefficient $\breve{K_f}(p_i(\Psi_X), p_j(\psi_Y))$ between the heuristic fuzzy soft points $p_i(\Psi_X)$ and $p_j(\psi_Y)$ on U is calculated as follows [6]:

$$\widetilde{K_f}(p_i(\Psi_X), p_j(\psi_Y)) = \frac{1}{3}\left[K_f^{\mu}\left(p_i(\Psi_X), p_j(\psi_Y)\right) + K_f^{\upsilon}\left(p_i(\Psi_X), p_j(\psi_Y)\right) + K_f^{\pi}\left(p_i(\Psi_X), p_j(\psi_Y)\right)\right] \quad (5)$$

Here;

$$K_f^{\mu}\left(p_i(\Psi_X), p_j(\psi_Y)\right) = \frac{\sum_{t=1}^{n}\left\{\left(\mu_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\mu_{p_i(\Psi_X)}(u_t)\right)\left(\mu_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\mu_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\mu_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\mu_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\mu_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\mu_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (6)$$

$$K_f^{\upsilon}\left(p_i(\Psi_X), p_j(\psi_Y)\right) = \frac{\sum_{t=1}^{n}\left\{\left(\upsilon_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\upsilon_{p_i(\Psi_X)}(u_t)\right)\left(\upsilon_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\upsilon_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\upsilon_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\upsilon_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\upsilon_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\upsilon_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (7)$$

$$K_f^{\pi}\left(p_i(\Psi_X), p_j(\psi_Y)\right) = \frac{\sum_{t=1}^{n}\left\{\left(\pi_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\pi_{p_i(\Psi_X)}(u_t)\right)\left(\pi_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\pi_{p_j(\psi_Y)}(u_t)\right)\right\}}{\left(\sum_{t=1}^{n}\left(\pi_{p_i(\Psi_X)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\pi_{p_i(\Psi_X)}(u_t)\right)^2\right)^{0.5}\left(\sum_{i=1}^{n}\left(\pi_{p_j(\psi_Y)}(u_t) - \frac{1}{n}\sum_{t=1}^{n}\pi_{p_j(\psi_Y)}(u_t)\right)^2\right)^{0.5}} \quad (8)$$

and $i = 1,2,\ldots,m = |X|$, $j = 1,2,\ldots,p = |Y|$. Also $|X|$ and $|Y|$ denotes the cardinality of X and Y, respectively.

Properties 2.2. Let Ψ_X ve ψ_Y be two intuitionistic fuzzy soft sets on U. Then the following statements are true [6];

(i) $\widetilde{K_f}\left(p_i(\Psi_X), p_j(\psi_Y)\right) = \widetilde{K_f}(p_j(\psi_Y), p_i(\Psi_X))$.

(ii) If $\Psi_X = \psi_Y$, then $\widetilde{K_f}\left(p_i(\Psi_X), p_j(\psi_Y)\right) = 1$.

(iii) $|\widetilde{K_f}\left(p_i(\Psi_X), p_j(\psi_Y)\right)| \leq 1$.

3. An Analysis of the Vaccine Technique Developed for the Covid-19 Pandemic

They are the most important technical vaccinations developed worldwide against the Covid-19 pandemic. Vaccination was carried out in 2 doses in Turkey. The start dates for these doses are January 14, 2021 for the first dose and February 11, 2021 for the second dose. In this section, an analysis of the epidemic in Turkey with vaccinations was made. For this, confirmed cases (patient /recovered /deceased) at the stage of combating the Covid-19 pandemic were selected as the dataset [7]. This analysis is structured in three different ways:

The first part: the phase without vaccination and the phase immediately after the first dose of vaccination has started,

The second part: The stage immediately after the first dose of vaccination and the stage immediately after the second dose of vaccination,

The third part: The phase with no vaccination and the phase with both doses of vaccination.

Thanks to this study, which focuses on these phases, we aim to reach a conclusion on how effective the vaccinations applied in Turkey can be despite the Covid-19 pandemic. For this, 14 days (January 1, 2021-January 14, 2021) before vaccination, 14 days (January 21, 2021-February 3, 2021) with the first dose of vaccinations, and finally 14 days with the administration of the second dose of vaccinations (February 18, 2021 - March 3, 2021) were selected. The choice of these dates is not random. January 21, 2021 and February 18, 2021 are the seventh days, with the start of the first and second doses of vaccines, respectively. The reason for this is the thought that more objective results can be achieved with vaccination (with the help of a 7-day time frame). Choosing the days before the vaccination as the days that are quite close to the vaccination is due to the assumption that it can more accurately reflect the post-vaccination activity.

Now, to perform this analysis in a near-optimal way, we propose an algorithm as follows:

Step 1: Select the part to be analysed.
Step 2: Identify the data for both phases to be evaluated for the selected part.
Step 3: Convert existing data to decimal values in the range [0,1].
Step 4: Find the correlation relationship between the phases using the correlation calculations given in Definition 2.6 and Definition 2.7.

The confirmed cases given in Table 1 were obtained through the Turkish Ministry of Health's Covid 19 Information Platform [7];

Table 1. Table label confirmed cases (Patient / recovered / deceased) [7]

Before vaccination	Patient	Recovered	Deceased	1. Post dose	Patient	Recovered	Deceased	2. Post dose	Patient	Recovered	Deceased
Jan 14, 2021	958	9.011	170	**Feb 3, 2021**	632	8.314	117	**Mar 3, 2021**	689	7.191	65
Jan 13, 2021	971	9.463	173	**Feb 2, 2021**	630	8.639	120	**Mar 2, 2021**	668	7.892	68
Jan 12, 2021	983	10.013	171	**Feb 1, 2021**	636	8.016	124	**Mar 1, 2021**	645	5.947	69
Jan 11, 2021	1.003	10.301	174	**Jan 31, 2021**	641	7.006	128	**Feb 28, 2021**	610	6.511	66
Jan 10, 2021	1.017	8.103	176	**Jan 30, 2021**	658	7.001	129	**Feb 27, 2021**	621	8.938	71
Jan 9, 2021	1.103	7.902	181	**Jan 29, 2021**	664	8.093	131	**Feb 26, 2021**	649	10.282	74
Jan 8, 2021	1.291	9.894	186	**Jan 28, 2021**	670	8.902	129	**Feb 25, 2021**	658	6.021	73
Jan 7, 2021	1.370	8.211	194	**Jan 27, 2021**	675	8.803	132	**Feb 24, 2021**	660	5.297	72
Jan 6, 2021	1.458	8.702	191	**Jan 26, 2021**	681	8.108	134	**Feb 23, 2021**	633	5.546	75
Jan 5, 2021	1.477	8.908	194	**Jan 25, 2021**	671	6.682	137	**Feb 22, 2021**	623	5.690	78
Jan 4, 2021	1.508	9.896	197	**Jan 24, 2021**	684	5.086	140	**Feb 21, 2021**	601	5.002	77
Jan 3, 2021	1.515	10.102	193	**Jan 23, 2021**	723	5.811	144	**Feb 20, 2021**	635	7.021	80
Jan 2, 2021	1.713	11.672	202	**Jan 22, 2021**	734	6.018	149	**Feb 19, 2021**	638	7.498	82
Jan 1, 2021	1.908	14.011	212	**Jan 21, 2021**	743	6.113	153	**Feb 18, 2021**	640	7.217	83

Table 2 is obtained by converting the data in Table 1 to decimal values.

Table 2. Confirmed cases in converted format

Before vaccination	Patient	Recovered	Deceased	1. Post dose	Patient	Recovered	Deceased	2. Post dose	Patient	Recovered	Deceased
Jan 14, 2021	0.0944	0.889	0.017	**Feb 3, 2021**	0.07	0.91735	0.01290	**Mar 3, 2021**	0.086	0.905	0.008
Jan 13, 2021	0.0915	0.892	0.016	**Feb 2, 2021**	0.067	0.920119	0.01278	**Mar 2, 2021**	0.077	0.915	0.007
Jan 12, 2021	0.0880	0.897	0.015	**Feb 1, 2021**	0.072	0.913400	0.01412	**Mar 1, 2021**	0.096	0.893	0.010
Jan 11, 2021	0.0873	0.897	0.015	**Jan 31, 2021**	0.082	0.901093	0.0164	**Feb 28, 2021**	0.084	0.906	0.009
Jan 10, 2021	0.1094	0.872	0.019	**Jan 30, 2021**	0.084	0.898947	0.01656	**Feb 27, 2021**	0.064	0.928	0.007
Jan 9, 2021	0.1200	0.86	0.02	**Jan 29, 2021**	0.075	0.910553	0.0147	**Feb 26, 2021**	0.058	0.934	0.006
Jan 8, 2021	0.1135	0.87	0.016	**Jan 28, 2021**	0.069	0.917637	0.01329	**Feb 25, 2021**	0.097	0.892	0.010
Jan 7, 2021	0.1401	0.84	0.02	**Jan 27, 2021**	0.07	0.916024	0.0137	**Feb 24, 2021**	0.1094	0.879	0.011
Jan 6, 2021	0.1408	0.841	0.018	**Jan 26, 2021**	0.076	0.908663	0.01501	**Feb 23, 2021**	0.101	0.887	0.011
Jan 5, 2021	0.1396	0.842	0.018	**Jan 25, 2021**	0.09	0.89212	0.0182	**Feb 22, 2021**	0.097	0.89	0.012
Jan 4, 2021	0.1299	0.853	0.017	**Jan 24, 2021**	0.116	0.860575	0.0236	**Feb 21, 2021**	0.105	0.881	0.013
Jan 3, 2021	0.1282	0.855	0.016	**Jan 23, 2021**	0.108	0.87017	0.0215	**Feb 20, 2021**	0.082	0.908	0.010
Jan 2, 2021	0.1260	0.859	0.015	**Jan 22, 2021**	0.106	0.872047	0.0215	**Feb 19, 2021**	0.077	0.912	0.009
Jan 1, 2021	0.1182	0.869	0.013	**Jan 21, 2021**	0.106	0.87216	0.0218	**Feb 18, 2021**	0.080	0.909	0.010

Based on the algorithm proposed in this section, analysis of all three parts can be made. For this, Table 3 is easily obtained by means of the correlation formulas given in Definition 2.6 and Definition 2.7.

Table 3. All correlation coefficients

Correlation	Patient	Recovered	Deceased	Net Correlation
PIECE 1	0.20170	0.34310	−0.38190	0.05429
PIECE 2	−0.01332	0.208005	0.41723	0.20396
PIECE 3	0.17000	0.35000	−0.04000	0.15780

4. Discussion on the Correlation between Vaccine Studies and the Covid-19 Outbreak across Turkey

With the help of the algorithm suggested in the previous section, correlation coefficients were obtained for all three parts of the confirmed cases (patient / recovered / deceased) obtained through the Turkish Ministry of Health Covid-19 Information Platform. With the help of these correlation coefficients calculated in this section,

• Number of cases for the unvaccinated stage,

• Number of cases after 1st dose of vaccine

• Number of cases resulting from the 2nd dose of vaccine

A relationship analysis was made between in this way; A comment can be made on how beneficial or harmful the vaccine studies for the Covid-19 epidemic in Turkey are. For this, we can interpret the correlation coefficients we obtained in Table 3:

• While the data obtained for each part of the analysis were calculated separately according to the number of sick, recovered and deceased persons, a net average correlation value was also calculated.

• When the 1st part and the 3rd part are compared, it is said that successful results are obtained against the pandemic with the progress of the vaccination process.

• When the 1st part and the 2nd part are compared, it is said that successful results are obtained against the pandemic with the progress of the vaccination process.

• When the 2nd part and the 3rd part are compared, it is said that better results are obtained against the epidemic with the vaccination process compared to the no-vaccination phase.

As a result of the current analyses obtained, we conclude that the vaccination process is a successful technique against the pandemic.

5. Conclusion

Many techniques have been developed to prevent further spread of this Covid-19 pandemic. One of the most important techniques developed against this pandemic is undoubtedly vaccination. In this study, the Covid-19 vaccination process in Turkey was analysed. For this analysis, confirmed cases (patient / recovered / deceased) obtained through the Turkish Ministry of Health Covid-19 Information Platform were chosen as the dataset. In addition, since the vaccination process in Turkey takes place in two doses, three different phases were selected as the period before the vaccination, the period between the 1st and 2nd dose vaccination period, and the period after the 2nd dose. In order to express the relationship between these phases, correlation coefficients were calculated for each phase by using intuitive fuzzy soft sets. Thus, it was aimed to measure the effect of the vaccination rate by analysing the number of people caught in the Covid-19 pandemic between each stage. We hope that this study can be a motivational tool for the analysis of other techniques for the Covid-19 pandemic.

Declaration of Ethical Standards

The authors of this article declare that the materials and methods used in their studies do not require ethical committee approval and/or legal-specific permission.

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