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Risk Assessment of Cognitive Development of Early Childhood Children in Quarantine Days: A New AHP Approach

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Abstract: The world is faced with disasters caused by natural or human effects from time to time. The various political, economic, health, and social consequences of these disasters affect people for different periods of time. In natural disasters and especially in epidemic diseases, some measures are taken to protect people from the negative effects of the situation. One of the measures that can be taken is quarantine. The target audience of this study is children aged 5-6 in the early childhood. Children of this age group are in the process of gaining skills in expressing their feelings during this period. In addition, the emotional responses of these children can be noticed by a careful observer or even an expert. The purpose of this study is to evaluate the risks of the effects of quarantine status related to COVID-19 pandemic on cognition and behavior of children staying at home. A new AHP technique was used to assess the risks of the quarantine process in early childhood children.

Keywords: COVID-19, early childhood, risk assessment, Pythagorean fuzzy set, analytic hierarchy process, cognitive development, behavioural development.

1 Introduction

Risk is always related to what can happen in the future. In today's world, risk can be accurately defined, analyzed and managed in a rational way. People knows that the probability of harmful events is a natural part of life. Such events can be caused by natural forces, such as flooding, lightning, natural disasters, or earthquake. Some harmful events can be foreseen and readily addressed, while other come unexpectedly because they appear foreseeable or have only a very remote likelihood of occurrence. Risk analysis is used to identify the causes of harmful events, to determine the possible consequences of harmful events, to identify and prioritize barriers, and to form a basis for deciding whether or not the risk related to a system is tolerable.

The aim of this study is to investigate the effects of quarantine status due to the COVID-19 pandemic on the cognitions and behaviours of children who stay at home. In this study, we first identified what possible cognitive an behavioral hazardous of COVID-19 quarantine could be in early childhood children. Secondly, we determined the answers to the probability of cognitive and behavioral changes in children and the possible consequences of their harms with qualitative statements. Finally, we assigned the cognitive and behavioral harmful states of children of the COVID-19 quarantine.

2 Preliminaries

Throughout the paper, the initial universe, parameters sets will denote $\mathcal{U}$, $\mathcal{P}$, respectively.

The FS has emerged as a generalization of the classical set concept. If we choose a non-empty set $\mathcal{U}$, then a function $m_{\mathcal{A}} : \mathcal{U} \to [0,1]$ is called *FS* on $\mathcal{U}$ and represented by

$$\mathcal{A} = \{(x_i, m_{\mathcal{A}}(x_i)) : m_{\mathcal{A}}(x_i) \in [0,1]; \forall x_i \in \mathcal{U}\}.$$

FS $\mathcal{A}$ on $\mathcal{U}$ can be expressed by set of ordered pair as follows:

$$\mathcal{A} = \{(x, m_{\mathcal{A}}(x)) : x \in \mathcal{U}\}.$$

The set

$$\mathcal{B} = \{(x, m_{\mathcal{B}}(x), n_{\mathcal{B}}(x)) : x \in \mathcal{U}\}$$

is called an *intuitionistic fuzzy set*(IFS) $\mathcal{B}$ on $\mathcal{U}$, where, $m_{\mathcal{B}} : \mathcal{U} \to [0,1]$ and $n_{\mathcal{B}} : \mathcal{U} \to [0,1]$ such that $0 \leq m_{\mathcal{B}}(x) + n_{\mathcal{B}}(x) \leq 1$ for any $x \in \mathcal{U}$ [1].

The degree of indeterminacy $p_{\mathcal{B}} = 1 - m_{\mathcal{B}}(x) - n_{\mathcal{B}}(x)$.

An *Pythagorean fuzzy set*(PFS) $\mathcal{C}$ in $\mathcal{U}$ is given by

$$\mathcal{C} = \{(x, m_{\mathcal{C}}(x), n_{\mathcal{C}}(x)) : x \in \mathcal{U}\},$$

where $m_{\mathcal{C}} : \mathcal{U} \to [0,1]$ denotes the degree of membership and $n_{\mathcal{C}} : \mathcal{U} \to [0,1]$ denotes the degree of non-membership of the element $x \in \mathcal{U}$ to the set $\mathcal{C}$, respectively, with the condition that $0 \leq [m_{\mathcal{C}}(x)]^2 + [n_{\mathcal{C}}(x)]^2 \leq 1$ [7–9].

The degree of indeterminacy $p_{\mathcal{C}} = \sqrt{1 - [m_{\mathcal{C}}(x)]^2 - [n_{\mathcal{C}}(x)]^2}$.

An interval valued PFS defined by Peng and Yang [5] as follows:

$$D = \{(x, m_{\mathcal{D}}(x), n_{\mathcal{D}}(x)) : x \in \mathcal{U}\}$$

where $m_{\mathcal{D}}(x) = \left[m_{\mathcal{D}}^{I}(x), m_{\mathcal{D}}^{J}(x)\right] \subset [0,1]$ and $n_{\mathcal{D}}(x) = \left[n_{\mathcal{D}}^{I}(x), n_{\mathcal{D}}^{J}(x)\right] \subset [0,1]$.

Cosine similarity is an angle-based measure of similarity between two vectors of n dimensions using the cosine of the angle between them. It measures the similarity between two vectors based only on the direction [2]. The cosine value of the angle between the two vectors expresses the similarity between the two vectors. Cosine similarity measures the angle between two vectors and calculates by dividing the inner product of those vectors by multiplication of their length [4]. In cosine similarity, the similarity between two users is between 0 and 1. The cosine similarity between two vectors d_i and d_j is formulated as follows:

$$sim_{cos}(d_i, d_j) = \frac{\overrightarrow{d_i}.\overrightarrow{d_j}}{\|\overrightarrow{d_i}\|.\|\overrightarrow{d_j}\|}. \tag{1}$$

3 Method

Weighted scales for PFAHP method are given in Table 1 [3, 6], where Linguistic terms Certainly Low Importance, Very Low Importance, Low Importance, Below Average Importance, Average Importance, Above Average Importance, High Importance, Very High Importance, Certainly High Importance, Exactly Equal are shown as α, β, γ, δ, ε, η, θ, λ, μ, φ, respectively.

The steps of Pythagorean fuzzy AHP are presented as follows:

Step 1. Construct the pairwise comparison matrix $E = (e_{ik})_{m\times m}$ as given in according to experts' evaluations based on Table 1.
Step 2. Obtain the differences matrix $F = (f_{ik})_{m\times m}$ with respect to lower and upper values of the membership and non-membership functions using Equations 2 and 3.
Step 3. Obtain the interval multiplicative matrix $G = (g_{ik})_{m\times m}$ by using Equations 4 and 5.
Step 4. Compute the determinacy value $H = (h_{ik})_{m\times m}$ of the e_{ik} by employing Equation 6.
Step 5. Multiply the determinacy values with $G = (g_{ik})_{m\times m}$ matrix to obtain the weights matrix before normalization, $T = (t_{ik})_{m\times m}$, by using Equation 7.
Step 6. Calculate the normalized priority weights ω_i by adopting Equation 8.

The new PFAHP method [6] is as follows:

Step 1. Identify work activities to determine the potential hazards and the interval valuation scale.
Step 2. Classify those hazards to form a hierarchy by consulting the partners and transform the problem into a hierarchy of goals and criteria.
Step 3. Generate binary comparison matrices for the criteria using range-valued sets based Table 1.
Step 4. Calculate the normalized criteria weights using the recommended interval valuation scale.
Step 4.1. The values in each column of the matrix are collected.
Step 4.2. After selecting the highest values for each parameter, each parameter is divided by the highest value selected.
Step 4.3. Calculate the average of each sequence to calculate the priority vectors.
Step 4.4. The steps above are repeated for each criterion and weight vectors are obtained for all. These procedures were repeated to obtain the priority weights of these criteria.
Step 5. Apply the cosine similarity measure between each alternative pair using the obtained priority weights.
Step 6. Using the linear regression function, the corresponding AHP score is assigned.
Step 7. Alternative weights were obtained based on the classic AHP steps.
Step 8. To be able to use the L matrix method, the probability and severity criteria of alternatives are rated according to alternative weights.
Step 9. Apply the L matrix method using the obtained grades.

Table 1 Weighted scales for the PFAHP

Linguistic terms	PFN equivalents IVPF numbers			
	m_I	m_J	n_I	n_J
α	0	0	0.9	1
β	0.1	0.2	0.8	0.9
γ	0.2	0.35	0.65	0.8
δ	0.35	0.45	0.55	0.65
ε	0.45	0.55	0.45	0.55
η	0.55	0.65	0.35	0.45
θ	0.65	0.8	0.2	0.35
λ	0.8	0.9	0.1	0.2
μ	0.9	1	0	0
φ	0.195	0.195	0.195	0.195

$$f_{ikI} = m_{ikI}^2 - n_{ikI}^2 \tag{2}$$

$$f_{ikU} = m_{ikJ}^2 - n_{ikJ}^2 \tag{3}$$

$$g_{ikI} = \sqrt{1000^{f_{ikI}}} \tag{4}$$

$$g_{ikJ} = \sqrt{1000^{f_{ikJ}}} \tag{5}$$

$$h_{ik} = 1 - \left(m_{ikJ}^2 - m_{ikI}^2\right) - \left(n_{ikJ}^2 - n_{ikI}^2\right) \tag{6}$$

$$t_{ik} = \left\{\frac{g_{ikI} + g_{ikJ}}{2}\right\} h_{ik} \tag{7}$$

$$\omega_i = \frac{\sum_{k=1}^{m} t_{ik}}{\sum_{i=1}^{m}\sum_{k=1}^{m} t_{ik}} \tag{8}$$

4 COVID-19 Quarantine Application

In order to determine the criteria to be measured, the cognitive and behavioral status of children should be taken into account when performing risk analysis in accordance with their attitudes in quarantine practice. For the weighting procedure, an aggregate of expert opinions consisting of evaluations of Early Childhood experts will be taken. After this stage, the sub-criteria and their weights will be used as inputs for both AHP methods to prioritize the goals and take the final decision. The experts in this study are people working on Early Childhood. Experts compare the criteria determined according to the cognitive and behavioral attitudes of these age children and express their evaluations.

The linguistic terms and their numeric labels are: For Questions to be asked to the child: Yes (1), maybe/some (2), no (3). For Questions to be asked to parents: too much (1), much (2), some (3), too little (4), none (5). The survey was prepared to be answered on the internet. Survey questions were asked to children aged 5-6 and their families. The survey included the following questions:

Questions to be asked to the child:

E1 Do you know Corona-virus?
E2 Does Corona-virus harm people?
E3 Does Corona-virus harm animals?
E4 Can Corona-virus be prevented?
E5 Are you afraid of Corona-virus?
E6 Do you think it's nice not to go to school?
E7 Are you upset that you can't go to school?
E8 Is the obligation to stay home boring?
E9 Can we be protected from Corona-virus by staying at home?
E10 Do you think you can go to school from now on?

Questions to be asked to parents:

P1 Does your child pay more attention to cleaning after Corona-virus?
P2 Has your child's sleep pattern been impaired after Corona-virus?
P3 Have there been changes in your child's nutritional habits after Corona-virus?
P4 Does your child behave anxiously after Corona-virus?
P5 Is your child afraid when a conversation about Corona-virus has passed?
P6 Does your child ask about Corona-virus?
P7 Did your child develop undesirable behaviour after Corona-virus?
P8 Is your child happy because she/he can't go to school?
P9 Has the time your child spent on the Internet after Corona-virus increased?
P10 Has the time your child spent in front of the TV increased after Corona-virus?

Table 2 Classifications of hazards about children's cognition

Current status information(CSI)	Children's COVID-19 knowledge	E1
	The idea of COVID-19 harming people	E2
	The idea of COVID-19 harming animals	E3
	Knowledge of to prevent COVID-19	E4
Affecting children's emotions(ACE)	Children's fear of COVID-19	E5
	Nice not to go to school	E6
	It's sad to not go to school	E7
	The boringness of staying in the compulsory home	E8
Affecting children's thoughts(ACT)	Being protected from COVID-19 by staying at home	E9
	To think that schools can be reopened	E10

Table 3 Classifications of hazards about children's behaviour

Change of basic habits of children(CBHC) in the quarantine period	Change in cleaning habits after COVID-19	P1
	Disruption in sleep pattern after COVID-19	P2
	Change in nutritional habits after COVID-19	P3
Change in behavioural after COVID-19(CB)	Anxiety increase after COVID-19	P4
	The emergence of fear when COVID-19 is spoken	P5
	Asking questions about COVID-19	P6
	Development of undesirable behavior after COVID-19	P7
	The idea that it is good not to go to school	P8
Change in behavior related to Information Technologies(CBIT)	increase in time spent on the internet	P9
	Increase in time spent in front of TV	P10

The cognitive and behavioral distributions of questions are as follows:

For children's cognition;

C1 Do children know about the current situation? (4 questions)
C2 Does the current situation affect children's emotions? (4 questions)
C3 Does the current situation affect children's thoughts? (2 questions)

For children's behavioral;

B1 Has Corona-virus changed the basic habits of children? (3 questions)
B2 Did behavior change occur in children after quarantine? (5 questions)
B3 Did children's behavior regarding information technologies increase after quarantine? (2 questions)

In this study, from Turkey, 201 children ages 5-6 units and 201 parents were the participants. Opinions of each child and each parent about the questions asked were got. The effect of quarantine on their own cognition in line with the answers given by the children and the effect of the behaviour of their children in line with the observations of the parents have been revealed.

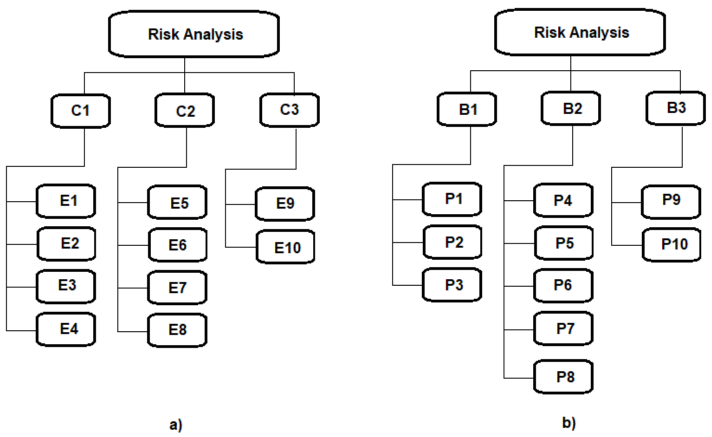

Fig. 1: Risk analysis a) for children's cognition, b) for children's behavioural

Risk factors were identified as a result of interviews and evaluations with Early Childhood experts. Basic problem and sub-problems related to this problem were created and data were obtained. The evaluations of early childhood experts were obtained for the weights with the acquired data. The risk analysis structure of children's and parents' evaluations is given in Figure 1. Cognitive and behavioral risks that can be classified

Table 4 Linguistic evaluations for CSI

	E1	E2	E3	E4
E1	φ	μ	θ	λ
E2	λ	φ	η	μ
E3	θ	δ	φ	γ
E4	μ	λ	ε	φ

Table 5 Linguistic evaluations for CB

	P4	P5	P6	P7	P8
P4	φ	ε	μ	μ	θ
P5	μ	φ	λ	μ	ε
P6	η	θ	φ	ε	γ
P7	μ	λ	θ	φ	ε
P8	β	γ	α	γ	φ

Table 6 Comparison matrix for probability

	E1	E2	E3	E4	sum
E1	0.195	0.8	0.5	0.2	1.695
	0.195	0.9	0.35	0.6	2.045
	0.195	0.65	0.8	0.55	2.195
E2	0.8	0.195	0.0	0.9	1.895
	0.9	0.195	0.45	1	2.545
	0.8	0.195	0.5	0.65	2.145
E3	0.8	0.45	0.195	0.8	2.245
	0.8	0.65	0.195	0.35	1.995
	0.65	0.5	0.195	0.6	1.945
E4	1	0.2	0.0	0.195	1.395
	0.9	0.4	0.55	0.195	2.045
	0.0	0.65	0.2	0.195	

Table 7 Normalized comparison matrix for probability

	E1	E2	E3	E4
E1	0.095	0.4	0.24	0.1
	0.095	0.44	0.17	0.3
	0.095	0.4	0.4	0.27
E2	0.31	0.08	0.0	0.35
	0.35	0.08	0.18	0.4
	0.31	0.08	0.2	0.255
E3	0.36	0.2	0.09	0.36
	0.36	0.29	0.09	0.16
	0.29	0.22	0.09	0.27
E4	0.49	0.1	0.0	0.1
	0.44	0.2	0.27	0.1
	0.0	0.32	0.1	0.1

Table 8 Weight for probability

	Weights		
E1	0.165	0.178	0.08
E2	0.107	0.136	0.093
E3	0.09	0.014	0.11
E4	0.055	0.08	0.142

in children are classified in Table 2 and Table 3. Linguistic evaluations for CSI and for CB are shown in Table 4 and Table 5, respectively.

For the weighting procedure, the sum of the assessments of the three experts was taken. After this step, in order to determine the priorities of the aims and make the final decision, the sub-problems and the their weights as PFAHP inputs are studied. Experts are early childhood employees and can compare specified problems, report results and indicate their evaluations.

Comparison matrices for probability owing to PFAHP are given in Table 6. The results in Table 6 indicate the experts evaluations about the criteria. Normalized comparison matrices for probability owing to PFAHP are given in Table 7.
Weights for probability are given in Table 8. It demonstrates the weight value for the criteria for CSI.

The same processes are carried out for severity. In addition, these procedures will be done for each classification of hazards. Table 9 will be obtained as a result of these processes.

Table 9 Weight for probability

Weights	Probablity	Severity	probability(P)	severity(S)	P × S
E1	0.01	0.021	1	2	2
E2	0.022	0.024	2	2	4
E3	0.013	0.029	1	3	3
E4	0.03	0.033	3	3	9
E5	0.038	0.042	4	4	16
E6	0.033	0.039	3	4	12
E7	0.021	0.018	2	2	4
E8	0.032	0.041	3	4	12
E9	0.028	0.03	3	3	9
E10	0.033	0.027	3	3	9
P1	0.024	0.018	2	2	4
P2	0.034	0.039	3	4	12
P3	0.027	0.042	3	4	12
P4	0.044	0.041	4	4	16
P5	0.039	0.042	4	4	16
P6	0.033	0.029	3	3	9
P7	0.032	0.04	3	4	12
P8	0.016	0.023	2	2	4
P9	0.034	0.043	3	4	12
P10	0.031	0.04	3	4	12

The results of the proposed approach owing to PFAHP are given in Table 9. According to these results, the criterion (E5) for cognition development and the criterions (P4) and (P5) for behaviour development have been found to be most critical factors. Further, the criterion (E1) for cognition development and the criterion (P8) for behaviour development have been found to the least critical factors.

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