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Selection of personal medical and health insurance company by using FUZZY TOPSIS

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ABSTRACT

There are many types of insurance offered by various number of companies. Medical and health insurance especially, has become a necessity today due to the expensive hospital bills and medical cost. Each company offers various type of packages for the customer to choose from. As a costumer, to make a decision on the selection of the right insurance company based on several criteria is quite challenging. Therefore, this study aims to help the customer in choosing suitable personal medical and health insurance by comparing 4 insurance companies based on 4 criteria. The evaluation from experts on each criterion against each alternative using linguistic variables were collected. The evaluation seem to have uncertainty and subjectivity. Therefore, this research used Fuzzy Techniques for Order Preference by Similarity to Ideal Situation (TOPSIS) method to rank the insurance companies since it is able to deal with the uncertainty and subjectivity of the data. The finding shows that Prudential holds the highest rank, followed by AiA, Great Eastern and Zurich.

Keyword: *TOPSIS; criteria: alternatives.*

INTRODUCTION

Insurance offers a protection from any financial loss and unexpected risk management, which can prevent from any uncertain loss. Insurance company is a private company whereby it is managed in accordance to the principle of self-responsibility (Yamamura & Mitamura, 2003). By having insurance, an individual is able to protect himself from risks such as natural disasters, accidents or even unfavourable events. Buying insurance is one of the most crucial financial decisions because it ensures financial stability if anything unfortunate happens. The demand of insurance in Malaysia has shown rapid growth in recent years. The demand for insurance is usually highly correlated with income, family structure and employment status (Luciano, Outreville, Rossi, 2015).
There are 3 types of insurance available in Malaysia; Life Insurance, General Insurance and Medical Insurance. Life Insurance helps cover risks like premature death, illness and permanent disability. It also pays out a certain amount of money to the insured or beneficiaries if anything bad happen to the insured (Smith & Hayhoe, 2009). Life Insurance Association of Malaysia (LIAM) Industry in 2015 said that up to 50%, which is around 12.5 million of Malaysia's population has life insurance coverage protection but 90% of them were under-covered. General Insurance includes Motor Insurance, Home Insurance, Personal Accident Insurance and Travel Insurance. Medical Insurance provides emergency cover for hospitalization, treatment and recovery.
In today's economy, Medical and Health insurance is necessary due to the increase of medical care cost. Based on the recent years' statistics, the cost of medical care expected to increase between 10% and 15% annually in Malaysia. Having a good health insurance plan becomes important because it helps a person to get better medical attention and therefore improves their quality of lives (Bovbjerg & Hadley, 2007). A person has no need to worry about handling the hospitalization costs. Some medical cards even cover pre- and post-hospitalization costs. With the right medical card, a person only has to worry about

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the recovery time rather than the bills. There are numerous companies in Malaysia that provides medicand health insurance. The consumers may have difficulty in choosing the most cost-effective policy that can meet their needs since there are many different criteria and measures.

Fuzzy TOPSIS is a useful method in the evaluation of alternatives on various criteria (Sodhi & Prabhakar, 2012). It can be practiced in many areas of study including economics, social sciences, engineering and medical sciences (Nadaban, Dzitac & Dzitac, 2016). Fuzzy TOPSIS was introduced by Hwang and Yoon in 1982 (World Congress on Engineering, Ao, and International Association of Engineers, 2011). Decision-making process are subjected to constraints, objectives and consequences. Most of the time, the decision and evaluation are very subjective and uncertain. Since Fuzzy TOPSIS enable us to deal with incomplete and uncertain knowledge and information, therefore it has become a popular method in many studies. A study done by Ashrafzadeh, Rafiei, Isfahani, and Zare (2012) used the Fuzzy TOPSIS to rank the location of five warehouses. Other researchers such as Srikrishna, Sreenivasulu and Vani (2014) conducted a study regarding selection of new car in the market.

Numerous studies have been conducted to help the public to make a decision on choosing the right insurance company according to certain criteria. Sahoo and Ratha (2018) did propose a recommender system which works on the multi-criteria decision making (MCDM) to rank life insurance policies. This application would help anyone to select the right policy with the right expectations. Jagdale. Jagdale, Venkataraman and Gupta (2014) and Puelz (1991) also have ranked the insurance companies but with the classical Analytic Hierarchy Process (AHP). Some other researchers such as Ilyas and Tunay (2015), Kahraman, Suder, and Turanoglu Bekar (2015) and Sehhat, Taheri and Sadeh (2015) have combined AHP and TOPSIS methods for ranking the insurance companies. In Malaysia, Leong and Noriza (2014) also used fuzzy TOPSIS to rank insurance companies that are preferred by customers in Federal Territory of Kuala Lumpur.

Methodology

This study uses the existing multi-criteria decision making (MCDM) called Fuzzy Technique for Order Preference by Similarity to Ideal Situation (TOPSIS) to rank the insurance companies against some selected criteria. In this method, an alternative that is close to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values (Kore, Ravi, and Patil, 2017). Besides, this technique is very reliable and suitable in order to solve the decision-making under fuzzy environment whereby the alternatives and criteria which under linguistic variable.

Data Collection

This study is conducted to rank the 4 leading insurance companies that offer personal medical and health insurance based on certain criteria. The companies are Prudential, AiA , Great Eastern and Zurich. Three experts were appointed for this purpose. Among them an academician who specialize in insurance, and two insurance consultants who are also insurance agents with several years of experience in the field. These experts are from Perlis, therefore their response is based on their experience in Perlis. The data on linguistic variables of criteria and alternatives are collected through interviewing the three decision makers. The decision makers were asked to evaluate each criterion with respect to each alternative with linguistic expression varying from “very poor” (VP) , “poor” (P), “fair” (F), “good”(G), and “very good” (VG), while, the importance of the criteria by expression of “very low”(LG) ,” low” (L), “medium” (M), “high” (H), and “very high”(VH) are used.

Basic Concept Fuzzy Set Theory

A fuzzy set $\tilde{a}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}(x)$ that maps of each element x in X in a real number in the interval [0, 1]. Therefore, the function value $\mu_{\tilde{a}}(x)$ is termed the grade of membership of x in $\tilde{a}$.

A Triangular Fuzzy Number

A triangular fuzzy number is denoted as a triplet $\tilde{a} = (a,b,c)$ and the membership function $\mu_{\tilde{a}}(x)$ of triangular fuzzy number $\tilde{a}$ is given as:

$$\mu_{\tilde{a}}(x) = \begin{cases} \frac{x-a}{b-a} & if\ a \le x \le b \\ \frac{c-x}{c-b} & if\ b \le x \le c \\ 0 & Otherwise \end{cases} \quad (1)$$

where a, b, c are real numbers and $a < b < c$. b gives the highest grade of membership function which is 1 meanwhile, c gives the least grade of membership function which is 0.

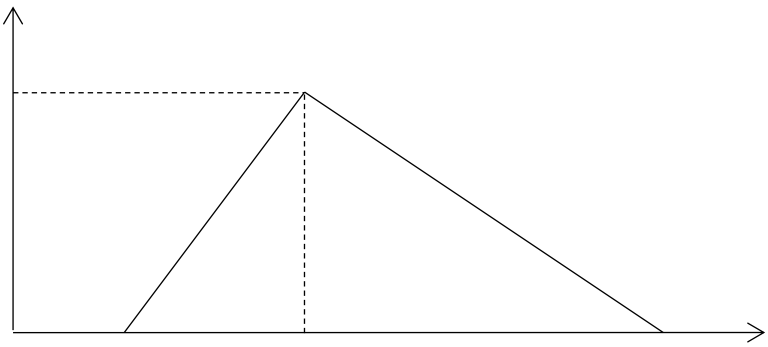

Figure 1: A triangular fuzzy number $\tilde{a}$

Distance Between Fuzzy Triangular Numbers

Let $\tilde{a} = (a_1, b_1, c_1)$ and $\tilde{b} = (a_2, b_2, c_3)$ be two triangular fuzz numbers. The distance between them is given by:

$$d(\tilde{a},\tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \quad (2)$$

Multiplication Between Fuzzy Triangular Numbers

Let $\tilde{a} = (a_1, b_1, c_1)$ and $\tilde{b} = (a_2, b_2, c_3)$ be two triangular fuzzy numbers. The multiplication between them is given by:

$$\tilde{a}\,(.)\,\tilde{b} = (a_1 a_2, b_1 b_2, c_1 c_2)$$

Linguistic Variables

The performance of the alternatives and the importance of criteria are evaluated with linguistic variables. The linguistic variables for performances are “very poor” (VP), “poor” (P), “fair” (F), “good” (G), and “very good” (VG). For representing the importance of the criteria the linguistic variables used are “very low” (VL), “low” (L), “medium” (M), “high” (H), and “very high” (VH). A linguistic variable is given a value in linguistic terms. Normally, the scales that have been used to rate the criteria and performance of the alternatives are from 1 to 9. The conversion of the linguistic variables into number are as given in table 1 below.

Table 1: Fuzzy Ratings for Linguistic Variable

Fuzzy Number	Performance of the Alternative	Importance of the Criteria
(1,1,3)	Very Poor (VP)	Very Low (VL)
(1,3,5)	Poor (P)	Low (L)
(3,5,7)	Fair (F)	Medium (M)
(5,7,9)	Good (G)	High (H)
(7,9,9)	Very Good (VG)	Very High (VH)

(Source: Sodhi and Prabhakar, 2012)

In this study there 4 alternatives that have been chosen namely, Prudential (A1), Zurich (A2), AiA (A3), and Great Eastern (A4). Meanwhile, there are 4 criteria that have been selected; Critical Illness Coverage (C1), Hospital Income (C2), Hospitalization and Surgical (C3) and Medical Card (C4).

TOPSIS

Fuzzy TOPSIS is the method, which is used to make a decision from various aspects. An alternative that is close to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values (Kore, Ravi, & Patil, 2017). Besides, this technique is very reliable and suitable in order to solve the decision-making under fuzzy environment whereby the alternatives and criteria which under linguistic variable.

Steps of fuzzy TOPSIS are as follows.

Step 1. Evaluation of performance assignment to the criteria and alternative.
Let say the decision group has K members. The fuzzy rating and importance weight of the kth decision maker, about the ith alternative on jth criterion, are $\tilde{x}_{ij}^{k} = \left(a_{ij}^{k}, b_{ij}^{k}, c_{ij}^{k}\right)$ and $\tilde{w}_{j}^{k} = \left(a'^{k}_{ji}, b'^{k}_{ji}, c'^{k}_{ji}\right)$ respectively, where $i = 1,2,...,m,$ and $j = 1,2,...,n.$

Step 2: Calculate the aggregate fuzzy assignment for criteria and alternatives.
The aggregated fuzzy ratings $\tilde{x}_{ij}$ of alternatives (i) with respect to each criterion (j) are given by $\tilde{x}_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right)$ such that:

$$a_{ij} = \min_{k}\left\{a_{ij}^{k}\right\}, \quad b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ij}^{k}, \quad c_{ij} = \max_{k}\left\{c_{ij}^{k}\right\}, \tag{3}$$

The aggregated fuzzy weights of each criterion are calculated as $\tilde{w}_{j}^{k} = \left(a'^{k}_{ji}, b'^{k}_{ji}, c'^{k}_{ji}\right)$ such that:

$$a'^{k}_{ji} = \min_{k}\left\{a'^{k}_{ji}\right\}, \quad b'_{ji} = \frac{1}{K}\sum_{k=1}^{K} b'^{k}_{ji}, \quad c'_{ji} = \max_{k}\left\{c'^{k}_{ji}\right\}, \tag{4}$$

Step 3. Calculate the fuzzy decision matrix.
A fuzzy Multi-Criteria Group Decision Making (MGDM) problem which can be briefly expressed in matrix format as:

$$\tilde{X} = \begin{matrix} & C_1 & C_2 & & C_n \\ A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ & \dots & \dots & \tilde{x}_{ij} & \dots \\ A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{matrix} \quad (5)$$

$$\tilde{W} = (\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_n) \quad (6)$$

Where for all $\tilde{x}_{ij}$ and $\tilde{x}_j, i = 1,2,\dots,m; j = 1,2,\dots,n.$ Here $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_j = (a'_j, b'_j, c'_j)$ are triangular fuzzy numbers representing linguistic variables.

Step 4. Normalize the decision matrix
To keep the normalization formula simple, the linear scale transformation is used to transform various criteria scales into a comparable scale. Thus, we have the normalized fuzzy decision matrix as:

$$\tilde{R} = [\tilde{r}_{ij}]_{m \times n}, i = 1,2,\dots,m; j = 1,2,\dots,n \quad (7)$$

where:

$$\left.\begin{aligned} \tilde{r}_{ij}^{+} &= \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad and \\ c_j^* &= \max_i c_{ij} \quad (benefit\ criteria) \end{aligned}\right\} \quad (8)$$

$$\left.\begin{aligned} \tilde{r}_{ij}^{-} &= \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \quad and \\ a_j^- &= \min_i a_{ij} \quad (\cos t\ criteria) \end{aligned}\right\} \quad (9)$$

The range of above normalized triangular fuzzy numbers is belongs to [0,1].

Step 5. Calculate the weighted normalize fuzzy decision matrix.
The weighted normalized fuzzy decision matrix $\tilde{V}$ is computed by multiplying the weights $(\tilde{w}_j)$ of evaluation criteria with the normalized fuzzy decision matrix $\tilde{r}_{ij}$ as:

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n},\ i = 1,2,\dots, m;\ j = 1,2,\dots, n \text{ where } \tilde{v}_{ij} = \tilde{r}_{ij}(.)\tilde{w}_h = (a''_{ij}, b''_{ij}, c''_{ij}) \quad (10)$$

Step 6. Calculate the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Solution (FNIS)
The FPIS and FNIS of the alternatives are defined as follows:

$$F^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \dots, \tilde{v}_n^+) \text{ where } \tilde{v}_j^+ = (1,1,1) \quad (11)$$

$$F^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-) \text{ where } \tilde{v}_j^- = (0,0,0) \quad (12)$$

Step 7. Calculate the distance from FNIS and FPIS for each alternative.
The distance $\left(d_i^+ \;\; and \;\; d_i^-\right)$ of each weighted alternative $i = 1,2,....,m$ from the FPIS and the FNIS is computed as follows:

$$d_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+), \qquad i = 1,,2,\dots,m \tag{13}$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \qquad i = 1,2,\dots,m \tag{14}$$

Where $d_v\left(\tilde{a}, \tilde{b}\right)$ is the distance measurement between two fuzzy numbers $\tilde{a}$ and $\tilde{b}$. This calculation will be measured by using vertex method like Eq. (2). The distances to fuzzy positive ideal solution F^+, and the fuzzy negative ideal solution F^- can be represented by the closeness coefficient simultaneously.

Step 8. Calculate the closeness coefficient of each alternative.
The formula below showed the closeness coefficient of each alternative:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}, \qquad i = 1,2,\dots,m \tag{15}$$

Step 9. Ranking the alternatives.
The alternatives of highest closeness coefficient represent FPIS which have the best alternative and close to 1 meanwhile FNIS is farthest from 0.

RESULT AND DISCUSSION

In this study, only four alternatives with four criteria are evaluated. The criteria selected are Critical Illness Coverage (C1), Hospital Income (C2), Hospitalization and Surgery (C3), and Medical Card (C4), while the alternatives are Prudential (A1), Zurich (A2), AiA (A3), and Great Eastern (A4). These variables will be used in order to identify the best selection of personal medical and health insurance company in Malaysia.
Table 2 shows the summarized data that has been collected from the three experts (decision makers). on personal medical and health insurance. Table 3 shows the importance of each criteria in the view of the experts.

Table 2: Collected data from the experts (Ei)

CRITERIA	A1			A2			A3			A4		
	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
C1	G	G	F	VG	G	F	F	F	G	G	F	F
C2	G	F	F	G	G	P	F	F	P	G	F	P
C3	VG	G	G	G	G	G	F	F	F	VG	F	G
C4	VG	G	G	G	G	VG	F	F	P	VG	G	P

Table 3: Linguistic Variable for Criteria

Criteria	E1	E2	E3
Critical Illness Coverage (C1)	VH	VH	H
Hospital Income (C2)	M	H	L
Hospitalization and Surgical (C3)	VH	VH	H
Medical Card (C4)	VH	VH	VH

The next step is to find the aggregated fuzzy weight for each alternative with respect to each criteria and also the aggregated fuzzy weight for each criteria by using equation (3) and (4). The results are shown in table 4 and table 5.

Table 4: Aggregated Fuzzy Weight for Alternative by DM (Decision Makers)

		A1	A2	A3	A4
C1	E1	(5,7,9)	(7,9,9)	(3,5,7)	(5,7,9)
	E2	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)
	E3	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)
Aggregate Rating		**(3, 6.333, 9)**	**(3,7, 9)**	**(3,5.667, 9)**	**(3,5.667, 9)**
C2	E1	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)
	E2	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)
	E3	(3,5,7)	(1,3,5)	(1,3,5)	(1,3,5)
Aggregate Rating		**(3, 5.667, 9)**	**(1,5.6667, 9)**	**(1,4.333, 7)**	**(1, 5, 9)**
C3	E1	(7,9,9)	(5,7,9)	(3,5,7)	(7,9,9)
	E2	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)
	E3	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)
Aggregate Rating		**(5, 7.667,9)**	**(5, 7, 9)**	**(3, 5, 7)**	**(3, 7, 9)**
C4	E1	(7,9,9)	(5,7,9)	(3,5,7)	(7,9,9)
	E2	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)
	E3	(5,7,9)	(7,9,9)	(1,3,5)	(1,3,5)
Aggregate Rating		**(5, 7.667, 9)**	**(5, 7.667, 9)**	**(1,4,333, 7)**	**(1, 6.333, 9)**

Table 5: Aggregated Fuzzy Weight for Criteria

Criteria	Experts			Aggregate Fuzzy Weight
	E1	**E2**	**E3**	
Critical Illness Coverage **(C1)**	(7,9,9)	(7,9,9)	(5,7,9)	(5, 8.333, 9)
Hospital Income **(C2)**	(3,5,7)	(5,7.9	(1,3,5)	(1, 5, 9)
Hospitalization and Surgical **(C3)**	(7,9,9)	(7,9,9)	(5,7.9	(5, 8.333, 9)
Medical Card **(C4)**	(7,9,9)	(7,9,9)	(7,9,9)	(7, 9, 9)

Now we have the decision matrix $\tilde{X}$ and $\tilde{W}$ as follow;

$$\tilde{X} = \begin{array}{c} \\ A1 \\ A2 \\ A3 \\ A4 \end{array} \begin{array}{c} \begin{array}{cccc} C1 & C2 & C3 & C4 \end{array} \\ \begin{pmatrix} (3,6.333,9) & (3,5.667,9) & (5,7.667,9) & (5,7.667,9) \\ (3,7,9) & (1,5.667,9) & (5,7,9) & (5,7.667,9) \\ (3,5.667,9) & (1,4.333,7) & (3,5,7) & .(1,4.333,7). \\ (3,5.667,9) & (1,5,9) & (3,7,9) & (1,6.333,9) \end{pmatrix} \end{array}$$

$$\tilde{W} = [(5, 8.333, 9) \quad (1,5,9) \quad (5, 8.333, 9) \quad (7,9,9)]$$

Next is to normalize the decision matrix according to benefit criteria and cost criteria using (8) and (9). For instance

$$\tilde{r}_{11}^{+} = \left(\frac{3}{9}, \frac{6.333}{9}, \frac{9}{9}\right) = (0.333, 0.704, 1) \text{ for benefit criteria and}$$

$$\tilde{r}_{11}^{-} = \left(\frac{3}{3}, \frac{3}{6.333}, \frac{3}{9}\right) = (1, 0.474, 0.333) \text{ for cost criteria.}$$

Table 6: Normalized Fuzzy Decision Matrix (Benefit Criteria)

	C1	C2	C3	C4
A1	(0.333, 0.704, 1)	(0.333,0.630, 1)	(0.556, 0.852, 1)	(0.556, 0.852, 1)
A2	(0.333, 0.778, 1)	(0.111, 0.630, 1)	(0.556, 0.778, 1)	(0.556, 0.852, 1)
A3	(0.333, 0.630, 1)	(0.111,0.481,0.778)	(0.333,0.556,0.778)	(0.111,0.481,0.778)
A4	(0.333, 0.630,1)	(0.111, 0.556, 1)	(0.333, 0.778, 1)	(0.111, 0.704,1)

$$\tilde{R}^{+} = \left\lfloor \tilde{r}_{ij}^{\ +} \right\rfloor_{4\times 4}, i = 1,2,3,4;\ j = 1,2,3,4$$

$$\tilde{R}^{+} = \begin{bmatrix} (0.333,\ 0.704,\ 1) & (0.333,\ 0.63,\ 1) & (0.556,\ 0.852,\ 1 & (0.556,\ 0.852,\ 1) \\ (0.333,\ 0.778, 1) & (0.111,\ 0.63,\ 1) & (0.556,\ 0.778,\ 1) & (0.556,\ 0.852,\ 1) \\ (0.333,\ 0.63, 1) & (0.111,\ 0.841, 0.778) & (0.333,\ 0.556,\ 0.778) & (0.111,\ 0.481,, 0.778) \\ (0.333,\ 0.63, 1) & (0.111,\ 0.556,\ 9) & (1.665, 6.483,\ 1) & (0.111,\ 0.704, 1) \end{bmatrix}$$

Table 7: Normalized Fuzzy Decision Matrix (Cost Criteria)

	C1	C2	C3	C4
A1	(1.000,0.474,0.333)	(1.000,0.529,0.333)	(0.600,0.391,0.333)	(0.600,0.391,0.333)
A2	(0.333,0.143,0.111)	(1.000,0.176,0.111)	(0.200,0.143,0.111)	(0.200,0.130,0.111)
A3	(0.333,0.176,0.111)	(1.000,0.231,0.143)	(0.333,0.200,0.143)	(1.000,0.231,0.143)
A4	(0.333,0.176,0.111)	(1.000,0.200,0.111)	(0.333,0.143,0.111)	(1.000,0.158,0.111)

$$\tilde{R}^{-} = \left\lfloor \tilde{r}_{ij}^{\ -} \right\rfloor_{m\times n}, i = 1,2,3,4;\ j = 1,2,3,4$$

$$\tilde{R}^{-} = \begin{bmatrix} (1,\ 0.474,\ 0.333) & (1,\ 0.529\ \ 0.333) & (0.6,\ 0.391,\ 0.333) & (0.6,\ 0.391, 0.333) \\ (0.333,\ 0.143,\ 0.111) & (1,\ 0.176,\ 0.111) & (0.2,\ 0.143,\ 0.1111) & (0.2,\ 0.13,\ 0.111) \\ (0.333,\ 0.176, 0.111) & (1,\ 0.231, 0.143) & (0.333,\ 0.2,\ 0143) & (1,\ 0.231,, 0.0.143) \\ (0.333,\ 0.176, 0.111) & (1,\ 0.2,\ 0.111) & (0.333,\ 0.143,\ 0.111) & (1,\ 0.158,\ 0.111) \end{bmatrix}$$

Next, calculate the weighted normalize fuzzy decision matrix by multiplying the normalized matrix by respective weight as given in equation (10).

$$\tilde{V}^{+} = \left\lfloor \tilde{v}_{ij}^{\ +} \right\rfloor_{4\times 4}\ i = 1,2,3,4;\ j = 1,2,3,4$$

$\tilde{v}_{11}^{+} = \tilde{r}_{11}^{+}(.)\tilde{w}_{1}$ = (0.333, 0.704, 1) (5, 8.333, 9) = (1.665,5.866,9.000) for benefit criteria.

$\tilde{v}_{11}^{-} = \tilde{r}_{11}^{-}(.)\tilde{w}_{1}$ = (1.000,0.474,0.333) (5, 8.333, 9) = (5.000,3.950,2.997) for cost criteria.

Table 8: Weighted Normalized Fuzzy Decision Matrix (Benefit Criteria)

	C1	C2	C3	C4
A1	(1.665,5.866,9.000)	(0.333,3.150,9.000)	(2.780,7.100,9.000)	(3.892,7.668,9.000)
A2	(1.665,6.483,9.000)	(0.111,3.150,9.000)	(2.780,6.483,9.000)	(3.892,7.668,9.000)
A3	(1.665,5.250,9.000)	(0.111,2.405,7.002)	(1.665,4.633,7.002)	(0.777,4.329,7.002)
A4	(1.665,5.250,9.000)	(0.111,2.780,9.000)	(1.665,6.483,9.000)	(0.777,6.336,9.000)

$$\tilde{V}^{+} = \left\lfloor \tilde{v}_{ij}^{\ +} \right\rfloor_{4\times 4}\ i = 1,2,3,4;\ j = 1,2,3,4$$

$$\tilde{V}^+ = \begin{bmatrix} (1.665,\ 5.886, 9) & (0.333,\ 3.15,\ 9) & (2.78, 7.1,\ 9) & (3.892,\ 7.668, 9) \\ (1.665, 6.483, 9) & (0.111,\ 3.15,\ 9) & (2.78, 6.483,\ 9) & (3.892,\ 7.668, 9) \\ (1.665, 5.25, 9) & (0.111,\ 2.405, 7.002) & (1.665, 4.663,\ 7.002) & (0.777,\ 4.329, 7.002) \\ (1.665, 5.25, 9) & (0.111,\ 2.78,\ 9) & (1.665, 6.483,\ 9) & (0.777,\ 6.336, 9) \end{bmatrix}$$

Table 9: Weighted Normalized Fuzzy Decision Matrix (Cost Criteria)

	C1	C2	C3	C4
A1	(5.000,3.950,2.997)	(1.000,2.645,2.997)	(3.000,3.258,2.997)	(4.200,3.519,2.997)
A2	(1.665,1.192,1.000)	(1.000,0.880,1.000)	(1.000,1.192,1.000)	(1.400,1.170,1.000)
A3	(1.665,1.467,1.000)	(1.000,1.155,1.287)	(1.665,1.667,1.287)	(7.000,2.079,1.287)
A4	(1.665,1.467,1.000)	(1.000,1.000,1.000)	(1.665,1.192,1.000)	(7.000,1.422,1.000)

$$\tilde{V}^- = \left[\tilde{v}_{ij}^-\right]_{4\times 4}\ i = 1,2,3,4;\ j = 1,2,3,4$$

$$\tilde{V}^- = \begin{bmatrix} (5,\ 3.95, 2.997) & 1,\ 2.645,\ 2.997 & (3,\ 3.258,\ 2.997) & (4.2,\ 3.519,\ 2.997) \\ (1.665, ,1.192,\ 1) & (1,\ 0.88.\ 1) & (1,\ 1.192, 1) & (1.4,\ 1.17,\ 1) \\ (1.665,\ 1.467,\ 1) & (1,\ 1.155,\ 1.287) & (1.665, 1.667, 1.287) & (7,\ 2.079.\ 1.287) \\ (1.665, 1.467,\ 1) & (1,1,1) & (1.665, 1.192,\ 1) & (7,\ 1.422,\ 1) \end{bmatrix}$$

The value of Fuzzy Positive Ideal Solution (FPIS) has been fixed to [1,1,1] in this research meanwhile the Fuzzy Negative Ideal Solution (FNIS) is [0,0,0] following Chen's Method (Chen, C.-T. ,2000).

Table 10: FPIS (F+) and FNIS (F-)

	F_i^+	F_i^-
C1	(1,1,1)	(0,0,0)
C2	(1,1,1)	(0,0,0)
C3	(1,1,1)	(0,0,0)
C4	(1,1,1)	(0,0,0)

Now, we calculate the distance for each alternative from FPIS (F^+) and FNIS(F^-) by using Equa (2), (13) and (14). For instance, the distance (d_v, A_1^+) and (d_v, A_1^-) for alternative A1 for C1 are calculated as follows

$$d_v(\tilde{v}_{11}^+, A_1^+) = \sqrt{\frac{1}{3}[(1.665-1)^2 + (5.866-1)^2 + (9-1)^2]} = 5.42$$

$$d_v(\tilde{v}_{11}^-, A_1^-) = \sqrt{\frac{1}{3}(5-0)^2 + (3.95-0)^2 + (2.997)^2} = 4.065$$

Table 11: Distance $d_i(A_i, F^+)$ for alternatives (benefit)

	(d_v, A_1^+)	(d_v, A_2^+)	(d_v, A_3^+)	(d_v, A_4^+)
C1	5.42	5.611	5.244	5.24
C2	4.798	4.81	3.596	4.76
C3	5.9	5.693	4.069	5.61
C4	6.24	6.24	3.965	5.553

$$d_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+), \qquad i = 1, ,2, \ldots, m$$

Table 12: Distance $d_i(A_i, F^-)$ for alternatives (cost)

	(d_v, A_1^-)	(d_v, A_2^-)	(d_v, A_3^-)	(d_v, A_4^-)
C1	4.065	1.316	1.405	1.405
C2	2.379	0.962	1.153	1
C3	3.087	1.068	1.55	1.316
C4	3.606	1.2	4.281	4.16

Calculate d_i^+ and d_i^- for each alternative where $d_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+)$, $i = 1, ,2, \ldots, m$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1, 2, \ldots, m$$

$$d_i^+ = 5.42 + 4.798 + 5.9 + 6.24 = 22.358$$

$$d_i^- = 4.065 + 2.379 + 3.087 + 3.606 = 13.137$$

Finally, calculate the closeness coefficient CC_i of each alternative using

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*}, \qquad i = 1, 2, \ldots, m \tag{15}$$

Table 13 shows the closeness coefficient and the ranking of alternative to Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS). This value are obtained by dividing the distance between alternative and FNIS with the both distance between alternative of FNIS and FPIS by referring in Eq. (15). For instance, in order to obtain the value of closeness coefficient for alternative A1, the value of distance between A1 and FNIS will be divided with the total distance for both FNIS and FPIS.

$$CC_1 = \frac{13.137}{13.137 + 22.358} = 0.3701$$

Table 13: The Closeness Coefficient of Each Alternatives

Alternative	Distance d_i^-	Distance d_i^+	CC_i	Rank
A1	13.137	22.358	0.3701	1
A2	4.54	22.354	0.169	4
A3	8.389	16.874	0.332	2
A4	7.881	21.16	0.27	3

From the closeness coefficients, the 4 insurance companies (alternatives) are ranked as in Table 13. The highest value for closeness coefficient is alternative A1 with 0.3701. The second highest is alternative A3 with 0.332, followed by alternative A4 with closeness coefficient of 0.27 and finally alternative A2 with 0.169; A1 > A3 > A4 > A2. In short, based on the four criteria in personal medical and health insurance which are Critical Illness Coverage, Hospital Income, Hospitalization and Surgical, and Medical Card, Prudential is on the top of the ranking, followed by AiA, Great Eastern and Zurich.

In this study, Fuzzy TOPSIS is used. In this method, an alternative that is close FPIS and farthest from the FNIS is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values. Fuzzy TOPSIS is very helpful in solving complex decision making involving many alternatives and criteria to be considered such as the selection of insurance company. The ambiguity in the linguistic scale in evaluation the alternatives and criteria are taken into account where fuzzy number is used. This is one of the advantages of using fuzzy TOPSIS in ranking the alternatives.

CONCLUSION

In conclusion, the finding of the study shows that the experts prefer Prudential the most, followed by AiA, Great Eastern and Zurich. The experts are an academician who specialize in insurance, and two insurance consultants who are also insurance agents with several years of experience in the field. The criteria in personal medical and health insurance which are Critical Illness Coverage, Hospital Income, Hospitalization and Surgical, and Medical Card. This research could be extended by using more insurance companies as the alternatives and more criteria to be considered. The policy holders from different background could be used as respondents. Besides Fuzzy TOPSIS method, other alternative techniques can be used such as Fuzzy AHP, Fuzzy DEMATEL, PROMETHEE and Yuen method. The rank can also be made on different types of insurance such General Insurance which includes Motor Insurance, Travel Insurance, Personal accident insurance and Fire/Householder Insurance.

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