Universiti Teknologi MARA
Cawangan Perlis
Jurnal Intelek

Volume 17 Issue 1 (February) 2022

Management of Obesity Using Fuzzy Analytic Hierarchy Process

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Received Date: 23 October 2021
Accepted Date: 27 December 2021
Published Date: 31 January 2022

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ABSTRACT

Obesity has been linked to several heart diseases. Unfortunately, Malaysians today are the most overweight or obese people among Asian nations. That is, half of the population is overweight. There are serious social consequences. Therefore, specific and serious actions are needed to reduce or eliminate this threat. The rapid increase in obesity rates has directed the link with the factors such as low physical activities, ease of transportation, food intake and emotional factor. Thus, this study aims at identifying the most significant factors affecting obesity in Peninsular Malaysia. The factors that are detected to be the cause of obesity can help manage individuals with obesity problems. The fuzzy Analytic Hierarchy Process (F-AHP) approach was used for the identification and ranking of each factor. The method adopted was one of the most reliable methods for both identification and ranking of the most significant factors affecting obesity. The study selected seven respondents and applied the calculations. The calculations consist of seven steps. Initially, the goals and criteria to construct the hierarchy process were determined. This was followed by the distribution of a questionnaire to the respondents using the linguistic scale. After that, two parameters were calculated, these include geometric mean weight and fuzzy weight. Lastly, the fuzzy weight and all the calculations were defuzzified and normalized. The results show the factors that affect obesity the most in Peninsular Malaysia is physical inactivity with a weight of 41.6% after being normalized. Physical inactivity has been ranked the first factor, food intake ranked second, the third rank is an emotional factor and lastly is technology. The precise identification and ranking are very meaningful to the management of the obesity problem. Firstly, there is a need to increase healthy physical activity. Secondly, they need to change their diet according to experts. Lastly, they need to manage their emotions and technology well. This study will enable the public to better understand the causes of obesity and help them to make the proper health adjustment to their lifestyle to achieve better health. The findings from this study also will assist the government in formulating a national health plan to tackle obesity among the public.

Keywords: Analytical Hierarchy Process, Fuzzy, Peninsular Malaysia, Management, Obesity

INTRODUCTION

World Health Organization (WHO) defines obesity as excessive fat accumulation that offers a hazard to fitness. It is normally because of the intake of extra energy that the body can use additionally known as corpulence or fatness. Obesity results when excess calories are stored as fat or adipose tissue. An

ISSN: 2231-7716 / E-ISSN 2682-9223
DOI: https://doi.org/10.24191/ji.v17i1.15858

individual's weight (in kilograms) is separated by the square of stature (in meters) is the count of the weight list of body mass index (BMI). When BMI calculation exceeds 30, it is generally known as obesity.

Jonathan (2018) states that unnecessary weight gain leading to overweight or obesity is now identified as a chronic or non-communicable disease. Obesity puts extra stress on our organs, joints and bones. It makes them have to work harder than they should. Too much fat in our body can raise cholesterol and blood pressure and are more likely to get heart attacks and strokes. Worse conditions will also occur such as back pain, osteoarthritis, sleep apnea and asthma. Excess fat will cause inflammation in turn damaging the cell. It is also associated with some types of cancer. Obesity also causes our body to respond less to insulin which controls blood sugar and these individuals will get type 2 diabetes.
Lum (2018) also mentions that obesity not only affects human body size but also can lead to major chronic diseases such as diabetes, cardiovascular diseases, stroke, gallstones and some cancers like breast, uterine and colon cancer. In addition to the physical effects, overweight children and obese adolescents often experience psychological problems such as nervousness, low self-esteem, depression and sadness (Chandani et. al., 2020).

Based on past studies, several factors contribute to obesity. The factors are technology influence (Bernadac et. al., 2019; Pagani et. al., 2010; Erica & Steven, 2016), physical inactivity (World Health Organization, 2019; Bauman et. al., 2009; Hazizi et. al., 2012; Rajappan, Selvaganapathy & Liew, 2015; Ying, Kuang & Ahmad, 2017), food intake (Garcia, Sunil & Hinojosa, 2012; Sturm, Roland & Hattori, 2015; Mejia 2016) and emotional factor (Jorm et. al., 2003; Khor, Cobiac & Skrzyprec, 2002; Hemmingsson, 2014). According to Ying, Kuang and Ahmad (2017), in Malaysia, about half (51.2%) of the adult population was overweight or obese (BMI $\geq$ 25). Besides, until 2016, the rates of overweight and obesity continue to increase among children and adults. Worryingly, the number of obese children who live in developing countries has risen by more than 30% which is higher than in developed countries (World Health Organization, 2019). Thus, the main objective of this study is to identify the significant factors that affect obesity in Peninsular Malaysia and to rank the relevant factors. The results will hopefully help obese individuals to plan their self-management in as to get out of the obesity problem.

LITERATURE REVIEW

Four factors contributed to obesity. The factors are the influence of technology, physical inactivity, food intake and emotional factors.

Technology Influence

Most young people nowadays use more information technology in their daily lives. This includes the use of mobile devices for learning, shopping, socializing, entertainment and so on. This leaves them more vulnerable to the influence of ads aggressively run by the food industry. According to Bernadac et. al., (2019), the amount of advertising and commercial promotion of high-fat, high-salt and high-sugar foods has significantly increased. Besides, every additional hour of television exposure at 29 months of age contributed to the higher consumption scores for a snack and soft drinks by about 10%, a decrease in activities involving a physical effort by 9% and a 5% unit increases in body mass index (Pagani et. al., 2010). Erica and Steven (2016) also proved the use of the highest level of screen devices, for five or more hours daily, was associated with significantly higher obesity by 95% of Confidence Interval (CI).

Physical Inactivity

Based on World Health Organization (2019), in 2016, approximately 13% of adults which is 15% of women and 11% of men were obese. This is because the growth of physical inactivity is due to the growing urbanization, increasing number of inactive natures of many types of jobs and changes in transportation modes. In a worldwide investigation of 20 countries, the reported percentage of physically inactive (sedentary) adults was China (6.9%) and Taiwan (42.3%) (Bauman et. al., 2009). Hazizi et. al (2012) in their research on Malay government employees recommend that accelerometer-determined physical activity level is an important factor related to obesity. Based on Rajappan, Selvaganapathy and Liew (2015), the amount of physical activity is linked to the status of the BMI. Ying, Kuang and Ahmad (2017) also found that physical activity in the lower level is associated with a higher risk of overweight or obesity.

Food Intake

In Malaysia, a changing environment and increasing access to varieties of food have widened food options and changed eating habits. According to Garcia, Sunil and Hinojosa (2012) result in fast food consumption has shown an increased pattern, the predicted probability of ordering through vendors which increase significantly. This indicates that unprecedented access to fast food consumption has strongly negative consequences. In addition to mobile access to food, the continued urbanization of Malaysia has contributed to access to various international and local food. This encourages individuals and groups to test varieties of food. Moreover, this habit increases the risk of obesity. Therefore, it is necessary to control overweight by introducing a healthy life such as using natural products and vegetable utilization, sugar-sweetened refreshment utilization, or fast-food admissions (Sturm, Roland & Hattori, 2015). According to Mejia (2016), the decrease in food prices also has a relative impact on taking more food and getting more obese.

Emotional Factors

The emotional aspect is all about the emotions of a person and how these can affect any outcome of an activity. This involves emotions that impairs self-control, trust and resilience. Anger, trust and fear also can be categorized as emotional factors. Based on Jorm et. al. (2003), obesity among women is associated with physical ill health, anxiety and depression. Furthermore, Khor, Cobiac & Skrzyprec (2002) in their study indicate that emotional and psychological factors have a significant influence on the eating habits of Malaysian university students which can lead to obesity. According to Hemmingsson (2014) model, psychological and emotional distress is a crucial factor between socioeconomic disadvantage and weight gain, in which children are particularly at risk.

Fuzzy Analytic Hierarchy Process (F-AHP)

Fuzzy pairwise comparison matrixes were constructed using linguistic evaluations in relation to the judgment of the decision-maker. There are several methods of Fuzzy Analytic Hierarchy Process (F- AHP) but for this study geometric mean method was used for the ranking and identification of the most criteria. The geometric mean method has been introduced by Buckley and Uppuluri (1987). The geometric mean technique is applied to calculate the fuzzy weights for every fuzzy matrix. These are blended commonly for the alternatives to decide the ultimate fuzzy weights. This study used geometric mean because this method can easily be applied in the process of fuzzifying the Analytic Hierarchy Process (AHP). According to Mahad, Yusof and Ismail (2019), F-AHP is used to solve ranking problems. The F-AHP is a combination of AHP hierarchical analysis and fuzzy set theory to make a single decision method and is an effective tool for dealing with qualitative assessment. It is advocated that for further research, the range of businesses that consists of unique linguistic scales sets and a variety of samples must be multiplied to acquire considerable discovery.

F-AHP is one of the decision-making tools which is widely applied in many multi-criteria ranking issues especially in health management. Nazari et. al. (2018) had developed an expert system that supports the Fuzzy Inference System and Fuzzy Analytic Hierarchy Process (FAHP) to judge the condition of heart disease patients. The Fuzzy Inference System was employed to assess and evaluate the likelihood of developing heart diseases in an exceedingly patient and FAHP was employed to calculate weights for various criteria that impact developing heart diseases. Many hospitals in Tehran have implemented the developed system and the results show the accuracy and efficiency of the developed approach. Furthermore, Mahat and Ahmad (2017) used the Fuzzy analytical hierarchy process to identify and select the best and the most effective thermal massage treatment session(s) required for diabetics to reduce blood glucose levels. The results showed that the most important criterion for successful thermal massage therapy was the number of therapy sessions (per day).

FAHP also can be applied in the education field (Çebi & Karal, 2017). Their study shows that the FAHP helps to evaluate the student projects and reduce the manual process. Besides, Nguyen et. al. (2015) used the Fuzzy Analytic Hierarchy Process in project complexity management to determine the weights of the components and parameters. This analysis deduced six components of project complexity, including socio-political, economic, operational, infrastructural, technical and scale complexity. As a result, socio-political complexity was the most defining component of transport construction complexity. Lan et. al. (2016) contributes to the use of FAHP in business management. It is proposed a model of customer satisfaction evaluation on logistics services and succeeded in determining the best company.

METHODOLOGY

The research employed primary data which were collected from the questionnaire feedback from the respondents which involves a group of experts as respondents. The group consist of medical assistants, doctors and personal trainers. The assessment of ranking the factors is made through interviews and handing out questionnaires to seven experts. The experts were dietitians from Hospital Tengku Ampuan Rahimah Klang, nutrition lecturers from Universiti Teknologi Mara (UiTM) Perlis, personal trainers and medical assistants. This study will identify factors that affect obesity the most and rank them accordingly. There was only one level of the hierarchy process which is technology influence (TI), physical inactivity (PI), food intake (FI) and emotional factors (EF). The details are presented in Figure 1.

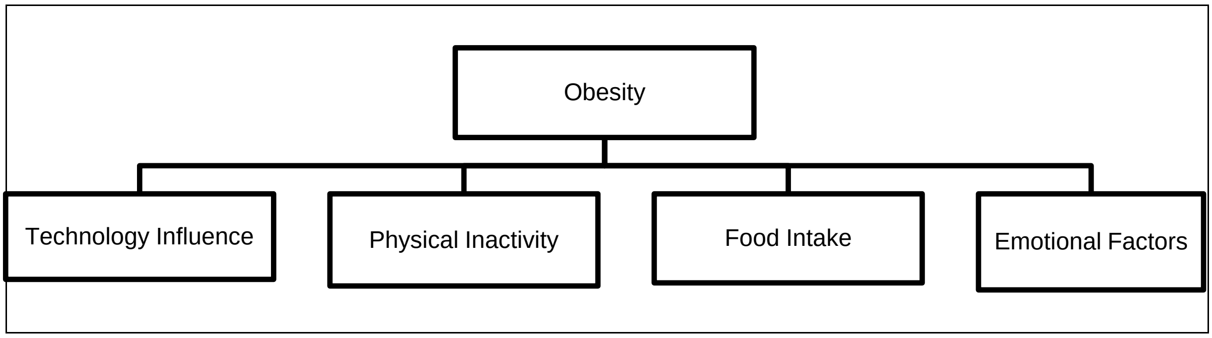

Figure 1: Hierarchy of factors

After questionnaires were distributed to the respondents, the data collected were then calculated in the following steps. This model is called the Fuzzy Analytical Hierarchy Process (F-AHP) and depended on the various-levelled structure. This method involves seven steps and the decision-maker follows these steps to rank the factors. The procedure of this method is described as follows:

Step 1: Identify the problem, goals, criteria and alternatives.
This step requires the researcher to figure out the problem, goals, criteria and alternatives based on the previous studies. It was then structured into a hierarchy of the F-AHP.

Step 2: Structure the hierarchy.
The hierarchy of the F-AHP was structured based on step 1. The hierarchical structure was developed with a top level as the goal, a second level as the criteria and a third level as the alternatives.

Step 3: Create a comparison matrix between the criteria in a triangular fuzzy number.
The relative importance of different criteria was determined concerning the goal. The scale of relative importance was used to create a Pairwise comparison matrix. The relative importance scale is also known as the linguistic term and converted to a triangular fuzzy number. The triangular fuzzy numbers are shown in Table 1.

Table 1: Triangular Fuzzy Number

Linguistic Variable	Scale	Triangular Fuzzy Number (p,q,s)
Equally Important (EI)	1	(1,1,1)
Intermittent value (I)	2	(1,2,3)
Weakly Important (WI)	3	(2,3,4)
Intermittent value (I)	4	(3,4,5)
Fairly Important (FI)	5	(4,5,6)
Intermittent value (I)	6	(5,6,7)
Strongly Important (SI)	7	(6,7,8)
Intermittent value (I)	8	(7,8,9)
Absolutely Important (AI)	9	(9,9,9)

Next, the decision-maker will decide on the importance of the criteria based on the Saaty scale. Matrix was set up to compare the criterion to another criterion. For example, if the first criteria were strongly important (FI) then, the fuzzy triangular number will be (4, 5, 6). Then, the comparability between the first and the second criteria will be $\left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right)$ as formulated shown in 3.2. The pairwise matrix of B_{ij} is shown below:

$$B = \begin{bmatrix} (1,1,1) & a_{12} & .. & .. & a_{1n} \\ a_{21} & (1,1,1) & .. & .. & a_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ a_{n1} & .. & .. & .. & (1,1,1) \end{bmatrix} \quad (1)$$

$B = a_{ij}$ where $a_{ij} = (p_{ij}, q_{ij}, s_{ij})$ and $i, j = 1,2,...,n$

$$\tilde{A}^{-1} = (p,q,s)^{-1} = \left(\frac{1}{s}, \frac{1}{q}, \frac{1}{p}\right) \tag{2}$$

Where $\tilde{A}^{-1}$ is the reciprocal triangular fuzzy number?

Step 4: calculate the geometric mean

Buckley (1987) stated that the geometric mean of fuzzy comparison values for each criterion is as shown in equation (3) denoting the triangular values as r_i :

$$\begin{aligned} r_i &= \left(\prod_{j=1}^{n} d_{ij}\right)^{\frac{1}{n}} \\ &= \left[(p_{i1}, q_{i1}, s_{i1}) \times (p_{i2}, q_{i2}, s_{i2}) \times ... \times (p_{in}, q_{in}, s_{in})\right]^{\frac{1}{n}} \\ &= (p_{ri}, q_{ri}, s_{ri}) \end{aligned} \tag{3}$$

Based on the hierarchy of ranking factors that have been established in Figure 1, a set of questionnaires were distributed to each of the respondents and they have assisted in the assessment process. The marked questionnaires are used by scale. Then, a pairwise comparison for each factor was created by using fuzzy triangular numbers that are stated in Table 1, revealing the strength of each pair of factors in the same hierarchy.

Table 2.1 until Table 2.7 presents the scale questionnaire from respondent 1 (R1) to respondent 7 (R7).

Table 2.1: Scale Questionnaire of R1

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
TI															X			PI
TI															X			FI
TI										X								EF
PI											X							FI
PI			X															EF
FI			X															EF

Table 2.2: Scale Questionnaire of R2

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T															X			PI
T																X		FI
T							X											EF
PI									X									FI
PI		X																EF
FI	X																	EF

Table 2.3: Scale Questionnaire of R3

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T																X		PI
T																	X	FI
T																X		EF
PI									X									FI
PI									X									EF
FI									X									EF

Table 2.4: Scale Questionnaire of R4

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T																	X	PI
T																	X	FI
T													X					EF
PI													X					FI
PI					X													EF
FI					X													EF

Table 2.5: Scale Questionnaire of R5

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T																	X	PI
T																	X	FI
T																	X	EF
PI	X																	FI
PI	X																	EF
FI	X																	EF

Table 2.6: Scale Questionnaire of R6

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T															X			PI
T															X			FI
T															X			EF
PI											X							FI
PI												X						EF
FI			X															EF

Table 2.7: Scale Questionnaire of R7

Option A	AI 9	I 8	SI 7	I 6	FI 5	I 4	WI 3	I 2	EI 1	I 2	WI 3	I 4	FI 5	I 6	SI 7	I 8	AI 9	Option B
T																X		PI
T																X		FI
T															X			EF
PI			X															FI
PI					X													EF
FI				X														EF

The following steps show the example of Fuzzy Analytic Hierarchy Process calculations. The next step is to make a pairwise comparison of the factors from respondent 1 (R1) answers.

Table 3: Pairwise Comparison of R1

Factor	TI	PI	FI	EF
TI	(1,1,1)	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$	$\left(\frac{1}{3},\frac{1}{2},1\right)$
PI	(6,7,8)	(1,1,1)	$\left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right)$	(6,7,8)
FI	(6,7,8)	(2,3,4)	(1,1,1)	(6,7,8)
EF	(1,2,3)	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$	$\left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right)$	(1,1,1)

After the respondent has been pairwise by the individual, then, each pairwise was compiled by using the average fuzzy number. Then, calculate the average and the new pairwise comparison is shown in Table 4. The following is an example of pairwise criteria of technology influence (TI).

$$\text{TI, TI} = \left(\frac{1+1+1+1+1+1+1}{7}, \frac{1+1+1+1+1+1+1}{7}, \frac{1+1+1+1+1+1+1}{7}\right)$$

$$= (1,1,1)$$

Table 4: New Pairwise Comparison

Factor	TI	PI	FI	EF
TI	(1,1,1)	(0.117, 0.129, 0.144)	(0.115, 0.124, 0.136)	(0.425, 0.603, 0.834)
PI	(7.143, 7.857, 8.571)	(1,1,1)	(2.524, 2.695, 2.857)	(4.457, 5.036, 5.619)
FI	(7.571, 8.143, 8.714)	(1.462, 1.893, 2.325)	(1,1,1)	(5.714, 6.286, 6.857)
EF	(4.750, 5.476, 6.214)	(0.669, 0.826, 0.989)	(0.255, 0.268, 0.287)	(1,1,1)

By using a new pairwise comparison, the geometric mean of fuzzy comparison values will calculate and the geometric mean is inserted into Table 5.

$$\text{TI} = \left[(1*0.177*0.115*0.425)^{\frac{1}{4}}, (1*0.129*0.124*0.603)^{\frac{1}{4}}, (1*0.144*0.136*0.834)^{\frac{1}{4}}\right]$$

$$= (0.275, 0.313, 0.358)$$

Table 5: Geometric Mean

Factor	Geometric mean		
T	0.275	0.313	0.358
PI	2.994	3.214	3.425
FI	2.820	3.138	3.433
EF	0.948	1.049	1.152

Step 5: Determination of fuzzy weight
This process requires finding the vector summation r_i, The formula is shown in Equation (4).

$$\text{Vector summation} = \sum r_i \quad (4)$$

The power of (-1) of the summation vector will be calculated. This is because the fuzzy triangular need to be replaced with the increasing order.

$$t^{-1} = \left(\frac{1}{\sum s_n}, \frac{1}{\sum q_n}, \frac{1}{\sum p_n} \right) \quad (5)$$

Next, fuzzy weight was found for each criterion by using Equation (6) below:

$$\begin{aligned} w_i &= r_i \times s^{-1} \\ &= \left(p_{w_i}, q_{w_i}, s_{w_i} \right) \end{aligned} \quad (6)$$

The reverse value is also calculated and arranged in increasing order as shown in Table 6.

Table 6: Reverse and Increasing Order

TOTAL	7. 037	7.713	8.368
REVERSE (TOTAL^{-1})	0.142	0.130	0.120
INCREASING ORDER	0.120	0.130	01.42

Then, the fuzzy weights are calculated by multiplying the geometric mean of fuzzy comparison with increasing order as shown in Table 7. The following example shows the calculation of fuzzy weight for criteria of Technology Influence (TI).

$$\begin{aligned} TI &= \left[(0.275 * 0.120), (0.313 * 0.130), (0.358 * 0.142) \right] \\ &= (0.034, 0.041, 0.051) \end{aligned}$$

Table 7: Fuzzy Weight

Factor	Fuzzy Weight
TI	(0.034, 0.041, 0.051)
PI	(0.368, 0.424, 0.490)
FI	(0.347, 0.414, 0.491)
EF	(0.117, 0.138, 0.165)

Step 6: Defuzzifying the fuzzy weight of criteria

The next step is important to defuzzify the fuzzy weight for every criterion involved by using the Centre of area method shown as described in Equation (7).

$$P_i = \frac{p_{w_i}, q_{w_i}, s_{w_i}}{3} \quad (7)$$

The fuzzy weight is then defuzzify divided by the sum of each factor by 3. The following example shows the calculation of Defuzzified weight for criteria of Technology Influence (TI). The defuzzified weight is then normalized to be tabulated in Table 8.

$$\begin{aligned} TI &= \frac{(0.034 + 0.041 + 0.051)}{3} \\ &= 0.042 \end{aligned}$$

Table 8: Defuzzied and Normalized Weight

Factor	Defuzzified	Normalized
TI	0.042	$\frac{0.042}{1.027} = 0.041$
PI	0.427	$\frac{0.427}{1.027} = 0.416$
FI	0.417	$\frac{0.417}{1.027} = 0.406$
EF	0.140	$\frac{0.140}{1.027} = 0.136$
Total	1.027	1.000

Step 7: Normalized the fuzzy weight of the criteria

Lastly, normalize the defuzzified weight criteria by using the formula in Equation (8).

$$Q_i = \frac{P_i}{\sum_{i=1}^{n} P_i} \tag{8}$$

RESULTS AND DISCUSSIONS

The fuzzy weight has been normalized and ranked the factors according to the normalized weight. Table 9 shows the ranking of the factors that affect obesity in Peninsular Malaysia based on the normalized weight.

Table 9: Ranking the factors based on normalized weight

Factors	Normalized	Ranking
TI	0.041	4
PI	0.416	1
FI	0.406	2
EF	0.136	3

The result shows that by ranking, the main factor that contributes to obesity is physical inactivity with a normalized weight value which is 0.416 (41.6%) followed by food intake with a 0.406 value (40.6%), then emotional factors score 0.136 (13.6%) and lastly, technology influence scores 0.041 (4.1%).

From the trend of these findings, it can be concluded that the most significant factor that affects obesity in Peninsular Malaysia today is physical inactivity which shows a percentage of fuzzy weight after normalized is 41.6% out of all the factors. This result was supported by Hazizi et. al (2012) who indicates accelerometer-determined physical activity level is an important factor associated with obesity among Malay government employees. Rajappan, Selvaganapathy and Liew (2015) declared that the amount of physical activity correlates with the BMI stage. Ying, Kuang and Ahmad (2017) also proved that a lower level of physical activity was related to a higher risk of obesity.

These precise identification and ranking are very meaningful to the obesity problem. This study suggests the implementation of weight-loss strategies. First, they need to increase healthy physical activity. After that, they need to change their diet according to experts. Lastly, they need to control and manage their emotions as well as the technology. These findings will enable the public to better interpret the causes of obesity and motivate them to make the proper health adjustment to their lifestyle to reach better health. The results from this study also will assist the government in formulating a national health plan to combat obesity among the public.

CONCLUSION

In conclusion, the study has achieved all the objectives since the most factor that affecting to obesity in Peninsular Malaysia is physical inactivity which scores 41.6%. It is followed by a food intake score of 40.6%, emotional factors score of 13.6% and lastly, technology is 4.1%. Based on the results, it is proved that Fuzzy-AHP is capable to rank the factors that contribute to obesity in Peninsular Malaysia. However, this study only focuses on four factors that contribute to obesity in Peninsular Malaysia. The selected factors were obtained from the observations of other researchers. The factors are physical inactivity, food intake, emotional factors and technology factor. This study aims to rank the relevant factors and identify the significant factor by using the Fuzzy Analytic Hierarchy Process (F-AHP).

This study might be enhanced by adding other alternatives and subfactors to be ranked. Introducing more respondents will give a worth value of reliability and validity. A further study recommends additional new factors and sub-factor such as age categories among the teenagers and adults, children and toddlers that are still in parental care. The sub-factors also should be added under emotional factors such as stress, anxiety and sadness. The relationship between specific factors and obesity needs to be observed to obtain more accurate results.

REFERENCES

Bernadac, M., Ghori, A., Cannenterre, J., Mou, N., & Moul, S. (2019). Children's obesity in the United States and the actions of the media. *International Conference of Scientific Paper*, 21-28.

Bauman, A., Bull, F., Chey, T., Craig, C. L., Ainsworth, B. E., Sallis, J. F. & Pratt, M. (2009). The international prevalence study on physical activity: results from 20 countries. *International journal of behavioral nutrition and physical activity*, *6*(1), 21.

Buckley, J.J. & Uppuluri, V. R. R. (1987). Fuzzy hierarchical analysis. In Uncertainty in Risk Assessment, Risk Management, and Decision Making. *Sringer, Boston, MA.*, 389-401.

Çebi, A., & Karal, H. (2017). An Application of Fuzzy Analytic Hierarchy Process (FAHP) for Evaluating Students' Project. *Educational Research and Reviews*, 12(3), 120-132.

Chandani, S., Pallavi, V., Madan, P., Om, P.K. & Mukundha (2020). Risk Factors Associated with Overweight and Obesity among Reproductive Aged (15-49) Years Females in Urban Areas of Rajbiraj Municipality, Saptari. *Advances in Obesity, Weight Management & Control*, 10(3), 84 - 88.

Erica, L.K. & Steven, L.G. (2016). United States Adolescents' Television, Computer, Videogame, Smartphone and Tablet use: Associations with Sugary Drinks, Sleep, Physical Activity and Obesity. *The Journal of Pediatrics*, 82, 144 - 149.

Garcia, G., Sunil, T. S., & Hinojosa, P. (2012). The fast food and obesity link: consumption patterns and severity of obesity. *Obesity surgery*, *22*(5), 810-818.

Hazizi, A. S., Aina Mardiah, B., Mohd Nasir, M. T., Zaitun, Y., Hamid Jan, J. M., & Tabata, I. (2012). Accelerometer-determined physical activity level among government employees in Penang, Malaysia. *Malaysian journal of nutrition*, 18(1).

Hemmingsson, E. (2014). A new model of the role of psychological and emotional distress in promoting obesity: conceptual review with implications for treatment and prevention. *Obesity Reviews*, 15(9), 769-779.

Jonathan, Q. P. (2018). Definitions, Classification and Epidemiology of Obesity. *Endocrinology Book.*

Jorm, A. F., Korten, A. E., Christensen, H., Jacomb, P. A., Rodgers, B., & Parslow, R. A. (2003). Association of obesity with anxiety, depression and emotional well-being: a community survey. *Australian and New Zealand Journal of Public Health*, 27(4), 434-440.

Khor, G. L., Cobiac, L., & Skrzypiec, G. (2002). Gender differences in eating behavior and social self-concept among Malaysian university students. *Malaysian Journal of Nutrition*, *8*(1), 75-98.

Lan, S., Zhang, H., Zhong, R. Y., & Huang, G. Q. (2016). A customer satisfaction evaluation model for logistics services using fuzzy analytic hierarchy process. *Industrial Management & Data Systems*.

Lum, M. (2018). Malaysia is Asia's Fattest Country. *The Star Malaysia.*

Mahad, N. F., Yusof, N., & Ismail, N. F. (2019). The application of fuzzy analytic hierarchy process (FAHP) approach to solve multi-criteria decision making (MCDM) problems. *Journal of Physics*, 1358, 1(012081).

Mahat, N., & Ahmad, S. (2017). Selection of the Best Thermal Massage Treatment for Diabetes by using Fuzzy Analytical Hierarchy Process. *Computing Research & Innovation (CRINN)*, 2, 34.

Mejia, N. (2016). *Three Essays on Obesity: Food Environment, Attitudes Toward Food, and Cash Transfers* (Doctoral dissertation, RAND).

Nazari, S., Fallah, M., Kazemipoor, H., & Salehipour, A. (2018). A fuzzy inference-fuzzy analytic hierarchy process-based clinical decision support system for diagnosis of heart diseases. *Expert Systems with Applications*, 95, 261-271.

Nguyen, A. T., Nguyen, L. D., Le-Hoai, L., & Dang, C. N. (2015). Quantifying the complexity of transportation projects using the fuzzy analytic hierarchy process. International journal of project management, 33(6), 1364-1376.

Pagani, L. S., Fitzpatrick, C., Barnett, T. A., & Dubow, E. (2010). Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. *Archives of pediatrics & adolescent medicine*, *164*(5), 425-431.

Rajappan, R., Selvaganapathy, K., & Liew, L. (2015). Physical activity level among university students: a cross-sectional survey. *International Journal of Physiotherapy and Research*, 3(6), 1336-1343.

Sturm, R., & Hattori, A. (2015). Diet and obesity in Los Angeles County 2007–2012: Is there a measurable effect of the 2008 "Fast-Food Ban"? *Social science & medicine*, *133*, 205-211.

World Health Organization (2019). Overweight and obesity (2019). *https://www.who.int/gho/ncd/risk_factors/overweight/en/*

Ying, Y.C., Kuang, K.L. & Ahmad, N.A. (2017). Physical activity and overweight/obesity among Malaysian adults: findings from the 2015 National Health and morbidity survey (NHMS). *BMC Public Health*, 17, 733.