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Public Perceptions of Cancer Risk using Analytic Hierarchy Process

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Abstract: This study aims to propose an analytical approach to rank risk levels of cancer. Analytic Hierarchy Process (AHP) model which incorporates five risk factors is constructed to rank five cancer types. A case study of perceptions of cancer risk levels is presented and the proposed model is applied to facilitate the decision process. A twenty five items questionnaire is employed to collect data from public at a residential area in Malaysia. The results show that lung cancer is ranked as the highest risk and prostate cancer is ranked as the lowest risk among the five cancer types. The overall ranking reflects the extent of awareness of cancer types and their risk factors among Malaysian public.

Key words: Decision making, pair-wise comparisons, human judgment, risk levels, ranking

INTRODUCTION

One of the most current significant discussions in medical fraternity is health problems related to cancer diseases. Cancer becomes one of the major health issues in the world and normally associated with life expectancy. In a very much frightening situation, cancer has been perceived as leading factor to premature death. In Malaysia, cancer is now the fourth leading cause of death among medically certified deaths. In the absence of a nationwide population-based cancer registry, the burden of cancer can only be estimated by extrapolating from regional surveys. According to Lim (2002), in a regional population-based cancer registry survey carried out between 1988 and 1990, the incidence rates for males and females were 56.3 and 56.9 per 100,000, respectively. This was probably an underestimate, as another regional cancer registry survey carried out in Penang in 1994 demonstrated that the incidence rates for all cancers was 115.9 per 100,000 for males and 119.7 per 100,000 for females. As under-reporting is known to be a significant problem in such surveys, the likely estimate is probably close to 150 per 100,000. The annual incidence of cancer in Malaysia has been estimated to be 30,000 (Lim and Lim, 1993). In 1998, Malaysia's population was 21.4 million, of whom 4% were aged 65 years and above. The incidence of cancer is expected to rise with an increase in aging population. The proportion aged more than 60 years was 4.6% in 1957, increased to 5.7% in 1990 and is projected to be 9.8% in 2020 (Karim,1997).

In a regional cancer registry surveyed by Kasri (1993), 10 leading cancer among males were lung, nasopharynx, stomach, urinary bladder, rectum, non-Hodgkin's lymphoma, larynx, liver, colon and oesophagus. Whereas, the ten leading cancer among females were cervix, breast, ovary, lung, nasopharynx, oesophagus, thyroid, colon, rectum and non-Hodgkin's lymphoma. In a national childhood cancer survey, the commonest childhood tumours were leukemias, tumours of the brain and spinal cord, lymphomas, neuroblastoma, gonadal and germ cell tumours, kidney tumours, soft tissue sarcomas and retinoblastomas. The crude incidence rate of paediatric malignancies in Malaysia was 77.4 per million children aged less than 15 years. Cancers with racial differences in incidence include nasopharyngeal cancer and oral cavity cancer. The incidence of nasopharyngeal cancer in males by race was 0.79 per 100,000 in Malays, 15.9 per 100,000 in Chinese and 1.1 per 100,000 in Indians while the corresponding incidence in females was 0.8, 4.1 and 0 per 100,000, respectively.

Despite its long alarming figures, what causes cancer or factors that associated with cancer are far from conclusive. Number of factors was believed to be associated with cancer and it varies depending on cancer types. For example, nasopharyngeal carcinoma revealed that smoking, working under poor ventilation, use of nasal balms or oil for nasal and throat troubles, use of herbal drugs and anti-EBV antibody titter were found statistically associated (Lin *et al*., 2006). It is also reported that increased body mass index levels are associated with an increased risk of cancer (Calle and Thun, 2004). And recently Song *et al*. (2008) reported that alcohol consumption may increase the risk of gastric cancer in women. Some other factors such as chemical exposure, family history of cancer and growing older are said to be among the factors that linked to cancer. But again, there are no reliable and concrete evidences to show the specific factors that can be linked to cancer. No single

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factor was claimed to be largely contribute to cancer. In other words there was no clear cut evidences to provide specific risk factor to cancer. In the midst of uncertainty, public may come with various unscientific presumptions toward factors that cause cancer. Public has been exposed to various information which is often conflicting or misleading concerning cancer risks. Little is known about the ways in which this information may have influenced public perceptions of cancer. It warrants further research to extract public perceptions of cancer and factors associated with cancer.

Since, perception is something intangible and linked with human judgment, thus a comparative evaluation model is proposed in decision making process. Based on mathematics and human psychology, Analytic Hierarchy Process (AHP) firstly proposed by Saaty (1980) and has been widely used to solve multiple-criteria decision-making problems. AHP, since its invention, has been a tool at the hands of decision makers and researchers and it is one of the most widely used multiple criteria decision-making tools (Vaidya and Kumar, 2006). The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals and for evaluating alternative solutions. Another important advantage of the AHP is that it allows for inconsistency in judgment and measures the degree to which the judgments are inconsistent and establishes an acceptable tolerance level for the degree of inconsistency. An extensive description of AHP in addressing comparisons and multi-attribute utility theory can be found by Dyer (1990a, b), Harker and Vargas (1990), Saaty (1990) and Winkler (1990). Therefore, this study aims to rank of the five cancer types in accordance with their risk levels from public perceptions using Analytic Hierarchy Process (AHP) which one of the structured techniques for dealing with comparative or ranking decisions.

Study of perceptions is one of the typical studies in many areas including health sciences. It has been studied with a number of methods from qualitative to quantitative approaches. In a study to find association between cancer risk perception and screening behavior among diverse women, Kim *et al.* (2008) use cross-sectional telephone and in-person interviews of women aged 50 to 80 years. The results from 1160 women were presented in percentages and confidence interval. Hay *et al.* (2002) surveyed oral cancer risk perception and risk behaviours among participants in a free oral-cancer screening. Again method of descriptive statistics and confidence level were presented to report the perception of smokers and lifetime tobacco exposure to the risk for cancer. Metcalfe and Narod (2002) study breast cancer risk perception among women who have undergone prophylactic bilateral mastectomy. Risk estimates were compared using Wilcoxon's signed-rank test and Pearson's product-moment correlation analysis.

Besides statistical approaches, there have been many studies in perceptions used qualitative approaches. For example, a qualitative approach was used by McMullin *et al.* (2008) to evaluate perception perceptions of cancer. Qualitative data from cancer related questions were collected via completed face-to-face, semi-structured interviews. Another qualitative research by Walker *et al.* (2007) aim to elicit the opinions of women who received standardized ear acupuncture protocol treatment delivered in small group clinics as an option to manage these side effects.

The present study takes a different perspective. Rather than use a typical statistical inferences and qualitative model, the approach advocated here uses a comparative evaluation model. The AHP technique uses a process of pair-wise comparisons to determine the relative importance or priority of alternatives in a multi-criteria decision making problem. The technique has been used in fields such as government, business, industry and healthcare. Chow and Luk (2005) used AHP framework to measure service quality in fast food restaurant industry. The AHP procedure provided a ranking order of firms with respect to the dimensions that define service quality. In a business related research, Kim and Hwang (2005) applied the analytic hierarchy process to the evaluation of customer-oriented success factors in mobile commerce. This study aimed explain the factors that affect success in mobile commerce and then evaluate and rate these factors by analyzing components of commercial activity in the mobile Internet environment using the AHP. Recently, Sambasivan and Fei (2008) used the AHP to find the relative weights and priorities of critical success factors and benefits among Malaysian companies in the electrical and electronics sector. The results were presented in the order of importance of critical success factors. The technique also extended to healthcare analysis and several studies have applied the AHP for the evaluation of health care facilities and in health care policy analysis. Very recently, Liberatore and Nydick (2008) reviewed extensively the application of AHP in medical and health care decision making.

Obviously, AHP has been successfully ranked all factors related to field of study. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem tangible or intangible, carefully measured or roughly estimated, well or poorly understood anything at all that applies to the decision at hand. Once, the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. In short, AHP is a multi-criteria decision method that utilizes structured pair-wise comparisons among systems of similar alternative strategies to produce a scale of preference.

METHOD OF AHP

The AHP is a selection process that consists of five steps as follow:

- **Step 1:** Decide upon the factor for selection:
  - Rate the relative importance of factors using pair-wise comparisons. Set up a matrix to compare each criterion to the others

$$A = \; a_{ij}\ (i, j = 1,2\ldots,n)$$
$$= \begin{bmatrix} 1 & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & 1 & & & a_{2n} \\ \cdots & & & & \cdots \\ \cdots & & & & \cdots \\ a_{n1} & \cdots & \cdots & \cdots & 1 \end{bmatrix}$$

  where, a_{ij} is integer and $0< a<10$ and a is a_{ij}, then $a_{ij} = 1/a$, then $a_{ij} = 1$ if $i = j$
  - Rank the degree of association of each criterion relative to the others, using the scale of association from 1 to 9

- **Step 2:** Find the eigenvector by normalised the pair-wise comparisons
  - Divide each entry by the total of its column:

$$A_{ij} = \frac{p_i}{p_j} \tag{1}$$

$$\frac{\frac{p_i}{p_j}}{\frac{\sum_{i=1}^{n} p_j}{p_j}} = \frac{p_i}{p_j} \times \frac{p_j}{\sum_{i=1}^{n} p_j} = \frac{p_i}{\sum_{i=1}^{n} p_j} \tag{2}$$

  - Divide total of row by the total of number of row:

$$\left(\frac{p_i}{\sum_{i=1}^{n} p_i} + \ldots + \frac{p_i}{\sum_{i=1}^{n} p_i} \right) \frac{1}{n} = \frac{n.p_i}{\sum_{i=1}^{n} p_i} . \frac{1}{n} = \frac{p_i}{\sum_{i=1}^{n} p_i} \tag{3}$$

- **Step 3:** Rate each factor relative to each other factor on the basis of degree of risk for each selection factor. This is achieved by performing pair-wise comparisons of the choices
- **Step 4:** Normalised the pair-wise comparisons
- **Step 5:** Combine the ratings derived in steps 2 and 4 to obtain an overall relative rating for each potential choice:

$$a_i = \Sigma_{wi} k_{ij} \tag{4}$$

Where:

a_j : Overall relative rating for factor i
w_i : Average normalised weight for factor i
k_{ij} : Average normalised rating for type j with respect to factor i

AN EMPIRICAL STUDY

In accordance with the purpose and method of this research, criteria and factors were identified. This research focuses on the Malaysian perceptions about the risk of getting cancer based on five selected factors. The five cancer types viz., breast, lung, throat, mouth and prostate were needed to be ranked according to their degree of risk based on the five selected factors. Each cancer type was perceived based on the premise that these five factors have been contributed to cancer. The five selected factors are alcohol, tobacco, ion radiation, obesity and genetic. The hierarchical structure of risk factors and cancer types are shown in Fig. 1. The first level stated the goal of the AHP. The second level addressed the relative risk of five cancer types. Respondents were asked to compare pairs of cancer types (for example breast vs. Lung) and to indicate whether they felt that one cancer type was equal risk to or absolute risk another cancer type. The third level of hierarchy compared the association of risk factors with respect to cancer type. The respondents were asked to state their preference for the risk factors in a pair-wise manner on a nine-point degree of association scale.

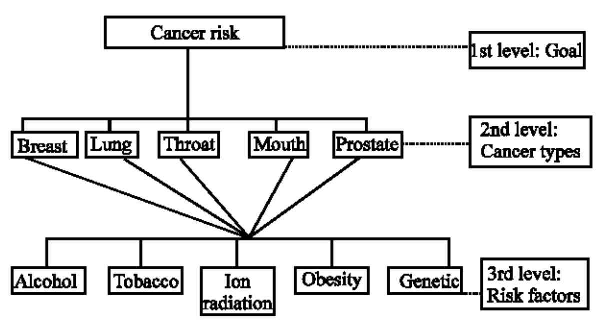

Fig. 1: Hierarchical structure of model in application

Data were collected at a residential area administrated by Kuantan Municipal Council in Peninsular Malaysia using a questionnaire prepared by the researhers. Data collection was conducted between 25 November 2007 and 22 December 2007 by the researchers. The twenty five items questionnaire was designed to meet the purpose of the study. One hundred and forty seven respondents were selected from different genders, ages, occupations and ethnics participated in a survey. The questionnaire consists of two parts with the first part contains the basic information of respondents. The second part of the questionnaire contains five questions to evaluate public perception of five factors with respect to the five cancer types. The perceptions were based on a nine-point relational scale of degree of association originally proposed by Saaty (1980). According to the scale used in this study, 1 represented equal associated, 2 represented equally associated to somewhat associated, 3 represented somewhat more associated, 4 represented somewhat associated to moderately associated, 5 represented moderately associated, 6 represented moderately associated to very associated 7 represented very associated 8 represented very associated to extremely associated to 9 represented extremely associated. Within each of these five questions, there were five sub-questions that compared between two cancer types. Again, the perceptions were based a nine point relational scale of degree of risks. The relationship between the factors and cancer types are explained using AHP. The steps as prescribed in the section Method of AHP are utilised throughout computations. The results are presented according to the following steps.

Step 1: The assigning weights as in the linguistic terms are used to find the pair-wise comparison of factors. These are shown in Table 1. The values reflect the association of the selected factors that possibly cause cancer.

Step 2: The weights in Table 1 are then normalised by dividing each entry in a column by the sum of all the entries in that column (Eq. 1, 2). By using the Eq. 3, the weights are averaged across the rows to give an average weight for each factor. The normalised pair-wise comparison of factors is shown in Table 2.

Step 3: The next step is the pair-wise comparison of the cancer types to enumerate how well the respondents rate with each factor. For each pair within each factor, the risk of cancer types is awarded a rating on a scale between 1 (equal risk) and 9 (absolute risk), whilst the other method in the pairing is awarded a rating equal to the reciprocal of this value. The results for the alcohol factor are given in Table 3.

Table 1: Pair-wise comparison for the risk factors

Factor	Alcohol	Tobacco	Ion radiation	Obesity	Genetic
Alcohol	1	1/8	4	7	6
Tobacco	8	1	6	9	7
Ion radiation	1/4	1/6	1	4	3
Obesity	1/7	1/9	1/4	1	1/2
Genetic	1/6	1/7	1/3	2	1
Column sum	9.56	1.55	11.55	23	17.5

Table 2: Normalized pair-wise comparison for the risk factors

Factor	Alcohol	Tobacco	Ion radiation	Obesity	Genetic	Row average
Alcohol	0.105	0.081	0.345	0.304	0.343	0.235
Tobacco	0.837	0.645	0.518	0.391	0.400	0.558
Ion radiation	0.026	0.108	0.086	0.174	0.171	0.113
Obesity	0.015	0.072	0.022	0.043	0.029	0.038
Genetic	0.017	0.092	0.029	0.087	0.057	0.056
Column sum	1	1	1	1	1	1

Table 3: Pair-wise comparison for cancer types

Cancer type	Breast	Lung	Throat	Mouth	Prostate
Breast	1	1/5	1/7	1/9	1/2
Lung	5	1	1/3	1/4	3
Throat	7	3	1	1/3	5
Mouth	9	4	3	1	6
Prostate	2	1/3	1/5	1/6	1
Column sum	24	8.53	4.68	1.86	15.5

Table 4: Average-normalized pair-wise comparison for cancer types and risk factors

	Factor				
Type	Alcohol	Tobacco	Ion radiation	Obesity	Genetic
Breast	0.038	0.035	0.480	0.571	0.493
Lung	0.145	0.487	0.280	0.073	0.073
Throat	0.272	0.267	0.066	0.038	0.135
Mouth	0.482	0.159	0.044	0.127	0.039
Prostate	0.064	0.052	0.130	0.233	0.260

Each entry in this matrix records how well the method corresponding to its row meets the alcohol factor when compared to the corresponding column. For example, the mouth's cancer was found to be a far more risk for alcoholic than breast cancer. The step 3 is executed for another four risk factors. Due to the limited space, the detailed results are not shown in this study.

Step 4: The ratings in these comparison matrices are normalised and averaged across the rows to give an average normalised rating by criterion for each cancer type. The step 4 is executed and the results are shown in Table 4.

Step 5: Combine the average normalized cancer type ratings with the average normalised factor weights to generate an overall rating for each cancer (Eq. 4). The extent to which the cancer type associates the factor is weighted according to the relative risk of the factor. Table 5 gives the results of this final step.

These results clearly show that lung cancer is the highest risk among the five cancer types based on the five

Table 5: Ranking of risk levels by cancer types

Cancer type	a_i	Ranking
Breast	0.132	4
Lung	0.344	1
Throat	0.229	2
Mouth	0.214	3
Prostate	0.082	5

selected factors. Throat cancer ranked at second place followed by mouth and breast cancer. Prostate cancer ranked at the lowest among the five cancer types.

CONCLUSION

The perception of risk to five cancer types has established by utilising a model in decision making. The model is a method for formalizing decision making where there are a limited number of choices but each has a number of factors and it is difficult to formalize some of those factors. The proposed model is used in determining the ranking of the cancer types according to the selected factors. In this experiment, data were collected based on phrases such as much more risk than to extract the decision makers preferences. The AHP has successfully applied in the process to decide the risk levels of cancer types based on the selected factors from respondents perspective. The results are drawn based on the ranking after executing several steps in AHP. Lung cancer perceived as the highest risk while prostate cancer perceived as the lowest risk. These results reflect the variability in perceptions about cancer and also the factors that may lead to cancer. Overall, this sample of the Malaysian population showed some degree of awareness of the various cancer types and the factors that might influence cancer risk. The awareness of cancer needs to be inculcated to public and more educational activities to be geared up in an effort to be at the best of quality of life of Malaysian specifically and the world population as a whole.

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