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Selection of Significant Lifestyle Risk Factor of Cancer by Hybrid X- Bar – DEMATEL-TOPSIS Method

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Abstract

The aim of this present study is to identify the most significant risk factor for cancer by means of a Statistical-MCDM model. The study begin with considering some types of cancer viz Lung, Colon and Rectum, Breast, Melanoma of the skin, Non-Hodgkin lymphoma, Kideny and Renal pelvis as well as Leukemia cancer as most of the cancer patients suffer from these types of cancers. X-Bar control chart is applied to sorting out the most lethal cancer among all cancer consider in this study and it is found that Lung and Bronchus cancer is the most fatal. Further we investigate the risk factor of all considering cancers by Decision-Making Trial and Evaluation Laboratory and Technique for Order Preference by Similarity to an Ideal Solution. All the risk factor have their own importance for death from cancer in medical aspects. Multi-Criteria Decision Making techniques are applied to recognize the most significant risk factor among all the factors in statistical scenario. It is identified that smoking is the most concerning risk factor. The information related from the study may help to take necessary measure to control the cancer.

Keywords: Cancer, Risk Factors, X- Bar, DEMATEL, TOPSIS

1. INTRODUCTION

Human body contains millions of cells; it grows divides and dies in conventional manner. Sometimes the system goes wrong and uncontrolled no of cells grows, which leads to cancer. The cancer cells combines and form extra mass tissue known as tumour [1]. Cancer is a common disease which spreads throughout the blood stream in the human body. Leukemia alters the blood cell and involve in its maturity and immaturity [2]. Some of the tumours does not spread throughout the body but grow uncontrollably like benign tumour [3]. Normal/healthy cell controls their growth and when they become unhealthy, destroys by themselves. In Asia high prevalence of chronic viruses like hepatitis B [4] and C, the Epstein Barr virus and human papillomaviruses (HPV) [4] increases the high risk of cancer. Mutations in p53 gene [5] leads to cancer as well as nutrition [6] play a vital role in mortality of cancer [7]. Exposure to aldehydes and formaldehyde associated with high risk of lymphoma cancer [8]. Hypoxia [9] is a solid tumour growth in cancer which is common and disturbs molecular pathways [10].

It is not possible to find out the specific cause for cancer. Cancer cells are modulated by culture condition and extracellular microenvironment condition [11]. But there are many risks which increase the cancer such as intake of tobacco, alcohol, poor diet, obesity, exposure of UV radiation, lack of physical activity [1].

According to the literature survey, there are so many lethal cancers namely Breast, Colorectum, Lung and Bronchus [12].

Of the 7 million deaths from cancer worldwide in 2001, an estimated 2·43 million (35%) were attributable to nine potentially modifiable risk factors. Of these, 0·76 million deaths were in high-income countries and 1·67 million in low-and-middle-income nations. Among low-and-middle-income regions, Europe and Central Asia had the highest proportion (39%) of deaths from cancer attributable to the risk factors studied. 1·6 million of the deaths attributable to these risk factors were in men and 0·83 million in women. Smoking, alcohol use, and low fruit and vegetable intake were the leading risk factors for death from cancer worldwide and in low-and-middle-income countries. In high-income countries, smoking, alcohol use, and overweight and obesity were the most important causes of cancer. Sexual transmission of human papilloma virus is a leading risk factor for cervical cancer in women in low-and-middle-income countries. More than 12 million new cases of cancer occur annually worldwide. Of those 5.4 million occur in developed countries and 6.7 million in developing countries [13, 14].

Aline, et al. developed the Proactive Molecular Risk Classifier for Endometrial Cancer (ProMisE), a molecular classification system based on The Cancer Genome Atlas genomic subgroups, and sought to confirm both feasibility and prognostic ability in a new, large cohort of ECs [15]. Evaluate the relationship between health beliefs (perceived susceptibility to breast cancer, perceived benefits of AI treatment, and perceived barriers to AI treatment) and adherence to AIs by Moriah, et al. [16]. Filip, et al. evaluated factors associated with stage-specific cancer therapy and survival focusing on temporal trends and sociodemographic disparities [17]. To identify the variability of short- and long-term survival outcomes among closed Phase III randomized controlled trials with small sample sizes comparing SBRT (stereotactic body radiation therapy) and surgical resection in operable clinical Stage I non-small cell lung cancer (NSCLC) patients by Pamela [18].

In the present study, we heave aimed to recognize the most fatal cancer and to find the most important factor (MIF) responsible for causing cancer. To carry out study, we have obtained the risk factors of cancer. Next, we have to find the rank of each factor by X-Bar control chart. In the second part of the study we have found out the most important risk factor of cancer by Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS).

2. BACKGROUND:

Cancer is the name given to a collection of related diseases. In all types of cancer, some of the body's cells begin to divide without stopping and spread into surrounding tissues. Cancer can start almost anywhere in the human body, which is made up of trillions of cells. Normally, human cells grow and divide to form new cells as the body needs them. When cells grow old or become damaged, they die, and new cells take their place [19]. Figure 1 showing a cancer cell. Figure 2 showing the new cancer cases annually per 100,000 people (age-adjusted) in the world. Table 1 showing description of cancers and also risk factors.

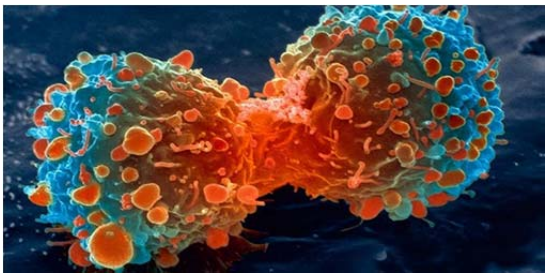


Figure 1: A dividing cancer cell (National Institutes of Health)

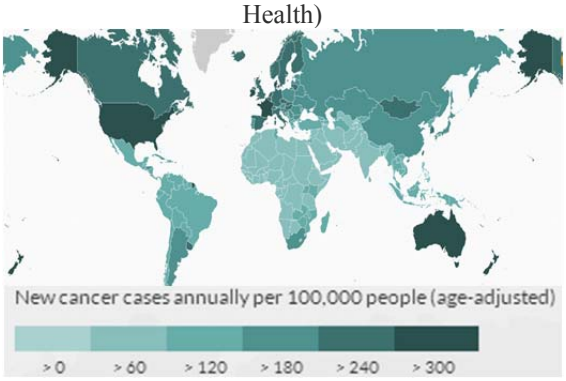


Figure 2: Recent cancer scenario in the world.

Table 1: Lifestyle Risk factors of cancer

Name of cancer	Description	Risk Factors
Breast Cancer	Advances in early detection and improved treatment for breast cancer have led to a steady decrease in overall breast cancer mortality rate; however, it remains a significant cause of morbidity and mortality. That lifestyle changes can enhance/retard the risk of developing breast cancer is supported by several lines of evidence. First, rates of breast cancer incidence vary widely by geographic areas around the world. Only a small part of these differences could be explained based on genetics, predisposition to chemical or carcinogen exposures have also been linked to risk, but most of cases are therefore, due to individual health and lifestyle behaviours. Women may improve their overall health and thus perhaps minimize breast cancer risk by low fat consumption, maintaining a healthy weight, avoiding cigarettes, limiting alcohol consumption, getting regular exercise and avoiding non-diagnostic ionizing radiation.	Obesity [20–24], Diet [25–29], Alcohol [30–33], Radiation [34–37]
Lung cancer	Lung cancer is the leading cause of cancer-related death and thus a major health problem. More than 90% of patients with lung cancer die of this disease. About 17.8% of cancer deaths are attributed to pulmonary carcinoma and 5-year survival rates are less than 10% [38]. Tobacco use has been reported to be the main cause of 90% of male and 79% of female lung cancers and about 90% of lung cancer deaths are estimated to be due to smoking [39]. The risk of the development of lung cancer in lifelong smokers is 20–40 times higher than non-smokers [40]. The risk of individual cancer development is determined by the balance between the metabolic activation and detoxification of the carcinogens in smoke. Metabolites occurring during the activation of carcinogens bind covalently with DNA and DNA adducts are formed which are regarded as an indicator of cancer risk in smokers [41]. Free radicals in cigarette smoke cause oxidative damage and mutations in DNA which leads to activation of oncogenes and inhibition of tumor suppressor genes.	Obesity [42–46], Diet [47–52], Alcohol [53–58], Smoking [59–66]
Colon cancer	Colorectal cancer is one of the leading causes of premature death in people worldwide. Due to the fact that malignant conversion of normal colonic cells requires several steps and often proceeds over considerable time periods, primary prevention of this process should include several approaches, with optimization of nutrition and diet being among most important.	Obesity [67–73], Diet [74–80], Alcohol[81–87], Smoking[88–93]

3. METHODS

In this study apply one Statistical namely X-Bar Control Chart and two MCDM method viz. DEMATEL, TOPSIS. X-Bar Control chart apply for find the rank of the factors. DEMATEL apply for selection of criteria. Also TOPSIS apply for selection of most important risk factor.

3.1. X-Bar Control Chart:

An X-Bar chart is used to monitor the average value, or mean, of a process over time. For each subgroup, the X-Bar value is plotted. The upper and lower control limits define the range of inherent variation in the subgroup means when the process is in control. This control chart basically based on five impotent steps:

1. Find the mean of each subgroup XBAR(1), XBAR(2), XBAR(3)... XBAR(k) and the grand mean of all subgroups using:

$$\overline{\overline{X}} = \frac{1}{k}\sum_{i=1}^{k} XBAR(i)$$

2. Find the UCL and LCL using the following equations:

$$UCL = \overline{\overline{X}} + A(2)RBAR$$

$$LCL = \overline{\overline{X}} - A(2)RBAR$$

$A(2)$ can be found in the following table-2:

3. Plot the LCL, UCL, centerline, and subgroup means.
4. Interpret the data using the following guidelines to determine if the process is in control:
   a. one point outside the 3 sigma control limits
   b. eight successive points on the same side of the centerline
   c. six successive points that increase or decrease
   d. two out of three points that are on the same side of the centerline, both at a distance exceeding 2 sigma's from the centerline
   e. four out of five points that are on the same side of the centerline, four at a distance exceeding 1 sigma from the centerline
   f. using an average run length (ARL) for determining process anomalies

3.2. Decision-Making Trial and Evaluation Laboratory:

One of the multiple criteria approaches proposed by Fontela and Gabus [94], known Decision-Making Trial and Evaluation Laboratory (DEMATEL) by which analyzing decisions only for criteria. DEMATEL) method [95, 96, 97] has been applied to illustrate the interrelations among criteria and to find the central criteria to represent the effectiveness of factors/aspects. In the current study, hence, utilize DEMATEL decision-making method to determine the importance weights of evaluation criteria. This decision making basically based on five impotent steps:

(i) Generating the direct-relation matrix: Consider the number of criteria is n. Construct a direct-relation matrix by $B_1=[b^{(1)}_{ij}]_{n\times n}$, $B_2=[b^{(2)}_{ij}]_{n\times n}$, $B_3=[b^{(3)}_{ij}]_{n\times n}$, ..., $B_m=[b^{(m)}_{ij}]_{n\times n}$ such that $A= [a_{ij}]_{n\times n}$

Where, $a_{ij} = \{b^{(1)}_{ij}+ b^{(2)}_{ij}+ b^{(3)}_{ij}+.....+ b^{(m)}_{ij}\}/m$, ∀ i, j = 1, 2, 3,....., n and i ≠ j.

$a_{ii} = 0$, ∀ i = j = 1, 2, 3,....., n.

Also B_1, B_2, B_3, ..., B_m denote the m number of experts is asked to make pairwise comparisons in terms of influence between criteria by an evaluation scale showing in table 3.

(ii) Normalizing the direct-relation matrix: For a fixed λ > 0 ∃ a normalized direct-relation matrix M such that M = λ A

Here taking $\lambda = \min \{(\max_i \sum_{j=1}^{n} a_{ij})^{-1}, (\max_j \sum_{i=1}^{n} a_{ij})^{-1}\}$

(iii) Obtaining the total-relation matrix: Since M is a n×n matrix then $(I - M)^{-1}$ must be exist and it is also n×n matrix. Where I is a n×n identity matrix. As M and $(I - M)^{-1}$ both are squire matrix and same order so $M(I - M)^{-1}$ must exist, called total-relation matrix and is denoted by $T=[t_{ij}]_{n\times n}$.

(iv) Compute the dispatcher group and receiver group: The sum of rows and the sum of columns of T are separately denoted as D and R.

$D = \sum_{j=1}^{n} t_{ij}$

$R = \sum_{i=1}^{n} t_{ij}$

The D + R value indicates the degree of importance that the corresponding criterion plays in the entire system. The factor having greater value of D + R has more interrelationships with other factors. On the other hand, criteria having positive values of D – R are on the cause group and dispatches effects to the other criteria. On the contrary, criteria having negative values of D – R are on the effect group and receive effects from the other criteria.

(v) Set up a threshold value to obtain the causal diagram: Since the total-relation matrix T provides the information on how one criterion affects another, decision maker group should set up a threshold value in order to filter out some negligible relationships. This way enables the decision maker to choose only the relationships greater than the threshold value and to map the cause-effect relationship accordingly. The causal diagram can be acquired by mapping the dataset of the (D + R, D – R) where the horizontal axis D + R and the vertical axis D – R.

Table 2. Selection of $A(2)$

n	2	3	4	5	6	7	8	9
$A(2)$	1.880	1.023	0.729	0.577	0.483	0.419	0.373	0.337

Table 3: Table showing evaluation scale for DEMATEL preferences [6]

Verbal judgments of preferences	Numerical rating
No influence	0
Low influence	1
Medium influence	2
High influence	3
High influence	4

3.3. Technique for Order Preference by Similarity to an Ideal Solution:

One of the multiple criteria approaches proposed by Chen and Hwang [98], known Technique for Order Preference by

Similarity to an Ideal Solution (TOPSIS) by which analyzing decisions for alternatives. The concept of TOPSIS is rational and understandable, and the computation involved is uncomplicated. Moreover, the inherent difficulty of assigning reliable subjective preferences to the criteria is worth noting [99]. In the current study, hence, we utilize a multi-criteria decision-making method to determine the importance weights of evaluation criteria, and TOPSIS method to obtain the performance ratings of the feasible alternatives. This decision making basically based on three impotent steps:

(i) Calculate the normalized decision matrix.
Consider the number of alternatives is m. Let normalized decision matrix $D = [r_{ij}]_{m\times m}$
The normalized value r_{ij} is defined by

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}, \forall\, i,j$$

(ii) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as

$$v_{ij} = w_j r_{ij}\ , \forall\, i,j$$

Where w_j is the weight of the jth criterion, and $\sum_{i=1}^{n} w_j = 1$

(iii) Determine the ideal and negative-ideal solution:

$$A^+ = \{v_1^+, v_2^+, v_3^+, \dots, v_m^+\} = \{(\max_i v_{ij} | j \in C_b), (\min_i v_{ij} | j \in C_c)\}$$

$$A^- = \{v_1^-, v_2^-, v_3^-, \dots, v_m^-\} = \{(\min_i v_{ij} | j \in C_b), (\max_i v_{ij} | j \in C_c)\}$$

Where C_b is associated with benefit criteria and C_c is associated with cost criteria.

(iv) Calculate the separation measures, using the m dimensional Euclidean distance. The separation of each alternative and negative from the ideal solution is given as:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^+)^2}\ , \forall\, i$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}\ , \forall\, i$$

(v) Calculate the relative closeness to the ideal solution: The relative closeness of the alternative A_i with respect to A^- is defined as

$$RC_i^* = \frac{S_i^-}{S_i^- + S_i^+}, \forall\, i$$

(vi) Rank the preference order. The index values of RC_i^* lie between 0 and 1. The larger index value means the closer to ideal solution for alternatives.

4. METHODOLOGY:

The main aim of the present investigation is selection of most important risk factor for cancer. The objective can be mathematically represented by Equations (1) and (2) where M represents the most important risk factor for cancer.

$$M = f(w, S) \quad \dots\dots (1)$$

If P denotes the lifestyle factors that affect the cancer, then

$$S = F(P) \quad \dots\dots (2)$$

And w is the weight of importance of each parameter. This weight of importance is evaluated by MCDM techniques, as described in Section 4.1.

4.1. Use of MCDM to estimate priority value of the factors in regard to present problem:

The MCDM methods comprise three steps namely
Selection of criteria
Selection of alternatives
Selection of ranking method
Application of aggregation method
The next sections explain the method by which criteria and alternatives were selected and the way aggregation method was applied.

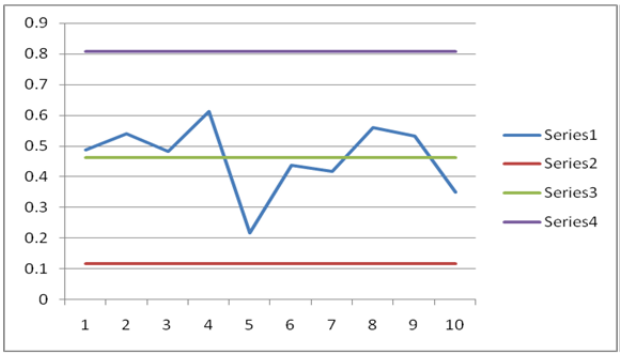
4.1.1. **Selection of Criteria:** In the present study we select the criteria by the intersection of Expert, Literature and Local hospital Survey by which death rate are increase. Here types of cancer consider as criteria.

Let, E= Set of Cancer suggested by Expert,
L= Set of Cancer selected by Literature Survey
H = Set of Cancer selected by Local Hospital Survey
E = { BC, LC, CC, LVC, UC }
L = { BC, LC, CC, PC, TC, NC}
H = { BC, LC, CC, MC, LVC, UC, NC}
Where, BC = Breast Cancer, LC = Lung Cancer, CC = Colon Cancer, PC = Prostate Cancer, UC = Urinary Bladder Cancer, TC = Thyroid Cancer, NC = Non-Hodgkin Lymphoma Cancer, MC = Melanoma of the Skin Cancer, LVC = Liver Cancer.
Therefore S = E ∩ L ∩ H = { BC, LC, CC }
So in the present study we consider Breast Cancer, Lung Cancer, and Colon Cancer as criteria.

4.1.2. **Selection of Alternatives:** In the present investigation we collect all these alternatives collect from literature survey. Here we consider all this risk factors of cancer consider as alternatives.
Therefore P = { O, D, A, SM }
O = Obesity, D = Diet, A = Alcohol, R = Radiation, SM = Smoking

4.1.3. **Selection of ranking method:** In this investigation criteria are selected as some Statistic Process Control (SPC) chart for finding the rank of the parameters based on its impact on the output. In this present study for finding the rank of each factor use some Statistic method. For finding the rank of sub criteria with respect to x-bar first collect some random data in (0, 1) for each criteria also corresponding priority value taken randomly in that range. Here taken the sample space is 5 and size is taken 50. In next step apply the efficiency index on this data then we get 4 sets of data corresponding to each criteria. Then apply x-bar on this index value. For finding the rank of each factor select that corresponding average weighted value in which average X-Bar value is maximum index (see in table 4).

Table 4: represents the computational procedure of X-Bar.									
	Here XBAR(1), XBAR(2), XBAR(3) and XBAR(4) are the index value.				Average	Max(XBAR(i)) – Min(XBAR(i))	X-Bar Control		
Sample	XBAR(1)	XBAR(2)	XBAR(3)	XBAR(4)	X-Bar	R-Bar	LCL	CL	UCL
1	0.203	0.386	0.863	0.088	0.385	0.774	0.14	0.446	0.7514
2	0.285	0.246	0.278	0.096	0.226	0.190	0.14	0.446	0.7514
3	0.488	0.688	0.347	0.327	0.462	0.361	0.14	0.446	0.7514
4	0.56	0.025	0.325	0.463	0.343	0.535	0.14	0.446	0.7514
5	0.412	0.437	0.596	0.404	0.463	0.192	0.14	0.446	0.7514
6	0.431	0.724	0.248	0.267	0.417	0.476	0.14	0.446	0.7514
7	0.841	0.421	0.954	0.413	0.657	0.541	0.14	0.446	0.7514
8	0.71	0.844	0.336	0.064	0.488	0.779	0.14	0.446	0.7514
9	0.083	0.557	0.867	0.263	0.443	0.784	0.14	0.446	0.7514
10	0.743	0.194	0.857	0.498	0.573	0.663	0.14	0.446	0.7514
				Average	0.446	0.530			



4.1.4. **Application of aggregation method:** In the present study, the DEMATEL method was applied for the identification of weight of importance of the criteria. A 3×3 matrix of criteria is developed to find the weight of the criteria. If B is the criteria matrix, then

B = { n(S)×n(S) } .....(3)

n(S) = ranking of each criteria collected from table 3.

Using DEMATEL method finds the priority value of criteria. For final aggregation apply TOPSIS method. For TOPSIS method constrict a normalized decision matrix by the help of S and P.

5. Result And Discussion

The results for this present investigation can be subdivided into one parts, viz., results of the MCDM method to estimate the weights of importance. The result is described in detail in the following different Section 5.1.

Result from MCDM:

Table 5 shows the rank of the criteria based on X-bar method. The rank of the parameters with respect to each of the criteria is presented in Table 6. Lung cancer (LC) and Smoking (SM) were found to be the most important criteria and alternative respectively. Least important criteria were found to be Colon Cancer (CC) and alternative with lowest significance was found to be Obesity (O). Table7 and 8 presents the weight vector of each of the criteria and parameters as found from the DEMATEL and TOPSIS MCDM methods respectively.

Table 5: Rank Of the Criteria	
Name of Criteria	Rank
Breast Cancer	2
Lung Cancer	1
Colon Cancer	3

Table 6: Rank Of the Alternatives	
Name of Alternatives	Rank
Obesity	4
Diet	5
Alcohol	2
Radiation	3
Smoking	1

Table 7: Value of D, R, D+R and D – R				
Criteria	D	R	D + R	D – R
CC	0.44058	0.556	0.99658	-0.1154
LC	0.40959	0.52639	0.93597	-0.1168
BC	0.51635	0.36059	0.87694	0.15576

Table 8: Weight Of the Alternatives	
Name of Alternatives	Weight
Obesity	0.14375
Diet	0.17500
Alcohol	0.21250
Radiation	0.20000
Smoking	0.26875

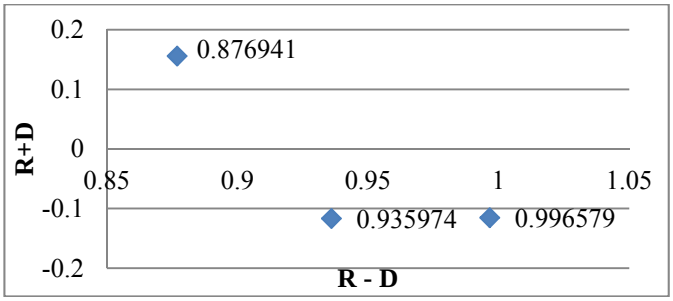


Figure 2: figure showing overall DEMATEL prominence–causal graphs

6. CONCLUSION:

In this study, we first find the Regression of death rate of cancer by making use of different kinds of cancers data. Investigation perfomed on three types of cancer viz. breast, colorectum as well as Lung.

The conclusions drawn from the above analysis are as follows:

a. Lung cancer is significant over other type of cancer.
b. Smoking is the most risk factor of all cancer.

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