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A Review on Multiple Criteria Decision Making in Tuberculosis Symptom

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Abstract—
Tuberculosis is a major public health problem. Rapid detection of the agent and effective treatment are two important factors in controlling the disease. The prognosis of Tuberculosis infection in lung, kidney, and liver is a complex phenomenon. The symptoms of Tuberculosis observed mostly from qualitative measures and with very few numerical data. The traditional single criteria decision-making approaches can no longer handle the complexity deal with this problem. Therefore, Tuberculosis decision making can be viewed as a multiple criteria decision-making problem with correlating criteria and alternatives. This paper reviews some multiple criteria decision making methods specifically from grey theory and illustrated these methods with few samples of TB affected patients.

Index Terms-- Tuberculosis(TB), latent tuberculosis infection(LTBI), Multiple criteria decision making (MCDM)

I. INTRODUCTION

TB is an infectious disease which transmitted from person to person. There are many different types of TB. A bacterium, Mycobacterium tuberculosis, causes the disease[1]. Risk factors for TB includes Clinical symptoms and signs of pulmonary TB include fever, night sweats, cough, hemoptysis (coughing up blood-stained sputum), weight loss, fatigue, and chest pain. Physicians definitively diagnose TB by culturing mycobacteria from sputum or biopsy specimens, but health-care professionals presumptively diagnose TB by history, physical exam, skin testing, and chest X-rays[2] . Treatment of TB infection is related to the type of TB infection and often requires extended treatments (months) with one or more anti-TB drugs. However, The traditional single criteria decision-making approaches can no longer handle the complexity deal with this problem.

MCDM was introduced as a promising and important field of study in the early 1970'es. Since then the number of contributions to theories and models, which could be used as a basis for more systematic and rational decision making with multiple criteria, has continued to grow at a steady rate. Multi-Criteria Decision Analysis has seen an incredible amount of use over the last several decades. Its role in different application areas has increased significantly, especially as new methods develop and as old methods improve.

At present the multi-criteria decision making methods are gaining importance for selection of best suited alternative among the available alternatives. Decision makers in the construction industry frequently face the problem of assessing a wide range of alternative options, and selecting one based on a set of conflicting criteria. MCDM methods are based on aggregating function representing "closeness to ideal"[3].

II. PARAMETERS AND RECOMMENDATION TEST USED FOR TB DIGNOSTICS

The following parameters have been identified for TB diagnosis, further classified as qualitative and quantitative measures.

A. Quantitative parameters:

- Fever- above 39 degree calicos
- Weight loss- about 40 to 50%
- Extreme back pain- 50 to 60%
- Anorexia- above 90%
- Cough with chest pain- above 80%

B. Qualitative parameters:

- Muscle tone- severely flabby
- Hemoptysis- present
- Breathing- difficulty in breath & irregular. Respiratory rate become shallow (<16/min)

- Sweating at night- cold sweating at night is present
- Headache- present

The noted parameter shows the TB infected measures, where patients then recommended for some tests.

The recommended test is given as follows:

a) Skin testing

The targeted tuberculin skin test (TST), also called the Mantoux test. It is the most accepted method of LTBI screening. When TB germs first enter your body, they causes latent TB infection. Without treatment, latent TB infection can become active TB infection [1]. The TB skin test is performed by injecting a small amount of fluid into the skin in the lower part of the arm. A person given the tuberculin skin test must return within 48 to 72 hours to have a trained health care worker look for a reaction on the arm.The health care worker look for a raised, hard area or swelling, and if present, measure its size using a ruler. Redness by itself is not considered as a part of reaction.

Recommended cutoff points for a positive reaction depend on the clinical setting :

- 5mm: high risk of developing active TB
- 10mm : some risk factor
- 15mm : no risk factor

b) Chest radiography

With pulmonary TB being the most common form of disease, the chest radiograph is useful for diagnosis of TB disease[1]. Chest abnormalities can suggest pulmonary TB disease. A posterior-anterior radiograph of the chest is the standard view used for the detection of TB-related chest abnormalities. In some cases, especially in children, a lateral view may be helpful[4].

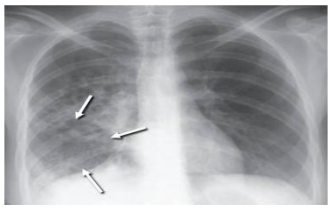

Figure1. Chest Radiograph with Lower Lobe Cavity

In pulmonary TB disease, radiographic abnormalities are often seen in the apical and posterior segments of the upper lobe or in the superior segments of the lower lobe.[5] However, lesions may appear anywhere in the lungs and may differ in size, shape, density, and cavitation, especially in HIV-infected and other immuno suppressed persons.[6] Middle and lower lung infiltrates are nonspecific but should prompt suspicion of primary TB in patients whose symptoms or exposure history suggests recent infection, particularly if there is pleural effusion[7].

c) Sputum induction

For diagnostic purposes, all persons suspected of having TB disease at any site should have sputum specimens collected for an AFB smear and culture, even those without respiratory symptoms[8]. At least three consecutive sputum specimens are needed, each collected in 8- to 24-hour intervals, with at least one being an early morning specimen. If possible, specimens should be obtained in an airborne infection isolation (AII) room or other isolated, well-ventilated area (e.g., outdoors) [1].

d) Drug susceptibility testing

For all patients, the initial M. tuberculosis isolate should be tested for resistance to the first-line anti-TB drugs: isoniazid, rifampin, ethambutol, and pyrazinamide. The results of drug-susceptibility tests should direct clinicians to choose the appropriate drugs for treating each patient.Patients with TB disease who are treated with drugs to which their strain of TB is resistant may not be successfully cured. In fact, their strain of TB may become resistant to additional drugs. Susceptibility results from laboratories should be promptly forwarded to the physician and health department.

III. DRAWBACKS IN ROUTINE TB DIAGNOSTICS METHODS

a) TB Skin Test:

- Administration requires staff training.
- The test cannot distinguish infection from disease, and needs to be followed by other conclusive tests to ensure appropriate treatment.

b) Chest Radiograph:

- Invisible to latent TB infection.
- Only used to detect pulmonary TB[9].
- HIV-positive patients with active TB commonly have abnormal x-rays not consistent with TB.

c) Sputum Induction :

- Requires special equipment.
- Sputum (need to contain 5000-10000 AFB/ ml.)
- Young children, elderly & HIV infected persons may not produce cavities & sputum containing AFB[10].

d) Drug Susceptibility:

- Low sensitivity for some compound.
- High cost of test.

IV. PROBLEM DEFINATION

Prevention of TB involves both early treatments to reduce transmission and isolation of the infected person until they are no longer contagious. The prognosis of TB infection in lung, kidney, and liver is a complex phenomenon. The infection is commonly detected through radio images. However, the symptoms of TB observed mostly from qualitative measures and with very few numerical data. The traditional single criteria decision-making approaches can no longer handle the complexity deal with this problem. TB decision making can be viewed as a multiple criteria decision-making problem with correlating criteria and alternatives.

V. MCDM METHODOLOGY

The proposed methodology includes different types of a Multi-criteria Decision Making Methods, a few of them are as follow:

1) The Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS):

The basic concept of this method is that the selected alternative is the one that has the best value for all criteria, i.e. the one that has the shortest distance from the negative ideal solution[11].TOPSIS is "an approach to identify an alternative which is closest to the ideal solution and farthest to the negative ideal solution in a multi-dimensional computing space".

The TOPSIS procedure is consists of the following steps:

Step1: Construct normalized the decision matrix.

$$rij = \frac{xij}{\sqrt{\sum_{i=1}^{m}(xij)^2}}$$

Step2: Calculate the weighted normalized decision matrix. The weighted normalized value vij is calculated as

$vij = wi\, rij$; where wi is the weight of the ith attribute

Step3: Determine the ideal and negative-ideal solution

$A+ = \{v1+, \ldots., vn+\}$ positive ideal solutions where

$vi+ = max(\,)$

$A- = \{v1-, \ldots., vn-\}$ negative ideal solutions where $vi- = min(\,)$

Step4: Calculate the separation measures for each alternative.

The separation from positive ideal alternative is

$S_I{}^{+} = \{\sum[(\,vi+) + (vij)]^2\}^{1/2}$ i =1,…,m

Similarly, the separation from negative ideal alternative is

$S_I{}^{-} = \{\sum[(\,vi-) - (vij)]^2\}^{1/2}$ i =1,…,m

Step5: Calculate the relative closeness to the ideal solution and then rank the preference order.

$$Ci = (Si-)\,/\,[(Si+) + (Si-)]$$

2) Simple Additive Weighting Method (SAW):

SAW is "a value function is established based on a simple addition of scores that represent the goal achievement under each criterion, multiplied by the particular weights" [3]. It has the ability to compensate among criteria. It is also intuitive to decision makers [12].The calculation is simple and can be performed without the help of complex computer programs.The steps of SAW can be described as follows:

Step1: Obtain the normalized decision matrix

$rij = xij/xj*$; $xj*$= max. No.of x in column of j

Step2: Obtain the weighted decision matrix by multiplying each column of normalized decision matrix by the corresponding weight & summing the weighted values to Evaluate each alternative, Ai by the formula:

$$Ai = \sum wj.rij$$

3) Compromise Ranking method (VIKOR):

The foundation for compromise solution was established by Yu(1973) and Zeleny (1982) and later advocated by Oprocovic and Tzeng (2002,2007) and Tzeng et al (2002, 2005). The compromise solution is a feasible solution that is the closest to the identical solution and a compromise means an agreement established by manual concession[13]. The compromise ranking algorithm VIKOR has the following steps:

Step1: Determine the best fi+ and the worst f i-values of all criterion functions

$$fi+ = max\,(fij)$$

$$fi- = min\,(fij)$$

Step2: Compute the values Sj and Rj by the relations

$$Sj = \sum_{i=1}^{n} \frac{wi[(fi+) - fij]}{[(fi+) - (fi-)]}$$

j =1,2...J

$$Rj = \max \frac{wi[(fi+) - fij]}{[(fi+) - (fi-)]}$$

Step3: Compute the values Qj, j = 1,2,...J, by the relation

$$Qj = [v(Sj - (S+)) \div ((S-) - (S+))] + [(1 - v)(Rj - (R+)) \div ((R-) - (R+))]$$

v = 0.5 ; introduced as a weight of strategy of the max. group utility

$S+ = min\ Sj$
$S- = max\ Sj$
$R+ = min\ Rj$
$R- = max\ Rj$

Step4: Rank the alternatives, sorting by the values S, R and Q, in decreasing order. The results are three ranking lists.

4) Grey Relational Analysis (GRA):

GRA is a new analysis method, which has been proposed in the Grey system theory and it is founded by Professor Deng Julong from Huazhong University of Science and Technology, People's Republic of China. GRA is based on geometrical mathematics, which compliance with the principles of normality, symmetry, entirety, and proximity[8]. GRA is suitable for solving complicated interrelationships between multiple factors and variables and has been successfully applied on cluster analysis, robot path planning, project selection, prediction analysis, performance evaluation, and factor effect evaluation and multiple criteria decision[14,15]. The step for GRA is given as follows:

Step1: implement the data normalization by

$$T = \min(x0, xi) / \max(x0, xi)$$

Step2: Deviation sequences of the reference sequence and comparability sequence

$$\Delta 0i = ||Xoj - Xij||$$

Where,
Xoj= the reference sequence
Xij= the comparative sequence

Step3: locate the grey relational coefficient

$$\xi\, i(k) = (\Delta\, min + \zeta\, \Delta\, max)/(\Delta 0i + \zeta\, \Delta\, max)$$

Δ min=0 & Δ max=1 and ζ =0.5

Step4: Grey relational grade can be calculated

$$\gamma 1 = 1/n \sum_{k=1}^{n} \xi\, j(k)$$

VI. SAMPLES AND PARAMETERS IDENTIFIED RANGES

For MCDM in TB detection, We have selected the 5 parameters of TB and the 5 samples of the patients. The ideal value is the specified value for No TB Symptoms. The data for a given patient is selected in such a way that patient P1 is severely infected with TB and patient P4 is normal patient.

Parameters	Ideal values	P1	P2	P3	P4	P5
Fever	0.10	0.50	0.40	0.44	0.20	0.25
Fatigue	0.15	0.30	0.55	0.34	0.20	0.40
Loss of appetite	0.10	0.80	0.10	0.24	0.18	0.35
Hemoptysis	0.17	0.68	0.15	0.48	0.18	0.25
Cough with expectoration	0.10	0.50	0.40	0.30	0.20	0.20

Table1. Parameters of TB with data of patients P1-P5

Ideally fever and fatigue must be at negligibly small value for no TB. Appetite becomes poor i.e. loss of appetite in terms of TB infected patients. Hemoptysis stands for coughing up blood from the mouth and long term cough with expectoration from 2-3 weeks makes the patient more infecting with TB.

For the given 5 parameters, there is a distribution of the 5 weights according to their priority in case of TB suggested by the specialist doctors. Such as W1=0.25, W2=0.075, W3= 0.1, W4=0.075, W5=0.5.

VII.MCDM IN TB DETECTION

1) GRA methodology-

Parameters	Ideal values	P1	P2	P3	P4	P5
Fever	1	0.2	0.25	0.22	0.5	0.4
Fatigue	1	0.5	0.27	0.44	0.75	0.37
Loss of appetite	1	0.12	0.1	0.41	0.55	0.28
Hemoptysis	1	0.25	0.88	0.35	0.94	0.68
Cough with expectoration	1	0.2	0.25	0.33	0.5	0.5

Table2. GRA Normalization

Parameters	Ideal values	P1	P2	P3	P4	P5
Fever	1	0.8	0.75	0.77	0.5	0.6
Fatigue	1	0.5	0.72	0.56	0.25	0.62
Loss of appetite	1	0.87	0	0.58	0.45	0.71
Hemoptysis	1	0.75	0.12	0.65	0.06	0.32
Cough with expectoration	1	0.8	0.75	0.67	0.5	0.5

Table3. GRA Deviation Sequence

Parameters	Ideal values	P1	P2	P3	P4	P5
Fever	1	0.38	0.4	0.39	0.5	0.45
Fatigue	1	0.5	0.40	0.47	0.66	0.44
Loss of appetite	1	0.36	1	0.46	0.52	0.61
Hemoptysis	1	0.4	0.80	0.43	0.89	0.60
Cough with expectoration	1	0.38	0.4	0.42	0.5	0.5

Table4. Grey Relational Coefficient

Parameter	P1	P2	P3	P4	P5
Summation	2.023	3	2.18	3.07	2041
Grade	0.40	0.60	0.43	0.61	0.48
Ranking	1	4	2	5	3

Table5: Grey relational grade and Ranking

2) SAW-

Parameters	P1	P2	P3	P4	P5
Fever	0.62	0.72	0.91	1	0.62
Fatigue	0.33	1	0.70	1	1
Loss of appetite	1	0.18	0.5	0.009	0.87
Hemoptysis	0.85	0.27	1	0.009	0.62
Cough with expectoration	0.62	0.72	0.62	1	0.5
Summation	0.657	0.659	0.71	0.826	0.615
Ranking	2	3	4	5	1

Table6. SAW Normalization and SAW weight decision Matrix with Ranking

3) TOPSIS-

Parameters	P1	P2	P3	P4	P5
Fever	0.38	0.5	0.53	0.46	0.37
Fatigue	0.23	0.68	0.41	0.46	0.60
Loss of appetite	0.61	0.125	0.29	0.41	0.53
Hemoptysis	0.52	0.187	0.58	0.41	0.37
Cough with expectoration	0.38	0.5	0.36	0.46	0.30

Table7. TOPSIS Normalization

Parameters	P1	P2	P3	P4	P5
Fever	0.096	0.125	0.013	0.11	0.09
Fatigue	0.017	0.051	0.03	0.03	0.04
Loss of appetite	0.061	0.012	0.02	0.04	0.05
Hemoptysis	0.039	0.014	0.04	0.03	0.02
Cough with expectoration	0.19	0.25	0.18	0.23	0.15

Table8. TOPSIS weight decision Matrix

Parameters	P1	P2	P3	P4	P5
A+	0.19	0.25	0.18	0.23	0.15
A-	0.017	0.012	0.029	0.031	0.028
$Si+$	0.26	0.40	0.25	0.33	0.19
$Si-$	0.19	0.26	0.19	0.21	0.14
Ci	0.426	0.39	0.43	0.37	0.421
Ranking	4	2	5	1	3

Table9. Positive and Negative Ideal Solution, Separation from positive and negative ideal alternative, Closeness to the ideal solution and ranking

4) VIKOR-

Parameters	P1	P2	P3	P4	P5
fi+	0.80	0.55	0.48	0.20	0.40
fi-	0.30	0.10	0.24	0.18	0.20

Table10. VIKOR Normalization

Parameters	P1	P2	P3	P4	P5
S1	0.15	0.08	0.04	0	0.18
S2	0.07	0	0.04	0	0
S3	0	0.1	0.1	0.1	0.025
S4	0.018	0.06	0	0.075	0.056
S5	0.3	0.16	0.37	0	0.5
Sj	0.54	0.41	0.55	0.175	0.76
Rj	0.3	0.16	0.31	0.1	0.5
Qj	0.56	0.27	0.66	0	1
Ranking	3	2	4	1	5

Table11. Values of Sj, Rj, Qj and Ranking

Rank	GRA	SAW	TOPSIS	VIKOR	Status
1	P1	P5	P4	P4	Extremely severe infected
2	P3	P1	P2	P2	Severe infected
3	P5	P2	P5	P1	Moderate infected
4	P2	P3	P1	P3	Mild infected
5	P4	P4	P3	P5	Normal

Table12. Tentative Outcome

VIII.CONCLUSION

By observing the deviated outcomes of GRA, SAW, TOPSIS, VIKOR methods, one can predict the tentative outcome of the TB infected patient. The weight consideration for various methods is decided as per the recommendation by specialist doctors. Ranking on the basis of severity from normal condition to extremely infected condition is judge using outcome from various MCDM methods. For scaling purpose data of a patient P1 is severely infected with TB and patient P4 is normal patient. While observing the outcomes from MCDM methods, GRA is caught to be found suitable in judging the patients severity.

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