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A Multi-Criteria Decision Making Model for Treatment of Helicobacter pylori Infection in Children

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Abstract Deciding upon a treatment regimen for management of *Helicobacter pylori* infection is an important concern which has been studied all around the world. Most studies focus particularly on the eradication rate of the regime by itself, however it seems that other factors such as the side effect of drugs or their cost can moreover affect the physician's decision for prescribing a suitable combination of drugs for a specific patient. A parent has the right in choosing between the different treatment options for her/his child. In order to evaluate and assess the best known alternative according to multi-criteria and considering the decision maker's preferences, a multi-criteria decision making model entitled "Analytical Hierarchical Process" (AHP) is employed. By this approach multi-criteria decision making analysis can be adapted to include both qualitative and quantitative criteria and their effects on selection of a proper regimen.

Key words Analytical Hierarchical Process; Children; Helicobacter pylori; Multi-criteria decision making model; Treatment regimen

Introduction

It is well known that Helicobacter pylori (H. pylori) infection plays a major role in the aetiology of chronic gastritis and peptic ulcer disease (PUD) in children.[1] Treatment of this infection is only recommended in those with H. pylori related PUD, or other complications of the infection.[2] Physicians need to be familiar with the most efficacious treatment regimes for eradication of H. pylori infection in children; on the other hand geographical regions worldwide vary in their H. pylori cure rates as a result of differences in hosts as well as H. pylori strains.[3] This is why many global studies have been carried out to evaluate the effectiveness of different regimens in the eradication of H. pylori infection. As in adults, eradication regimens for H. pylori infection in children are a combination of various antibiotics, anti-acids and bismuth salts.[4] Studies by Oderda et al and many others have shown that regimens containing only one antibiotic are not effective in eradication of the infection.[5,6] Nowadays dual antibiotic therapy combined with anti-acids, with or without bismuth salts are recommended.[4] Different combinations of antibiotics with a variety of dosages have been studied worldwide in order to find the best choice for eradication of H. pylori infection in each region. Of the effective treatments studied we can point to triple therapies such as Amoxicillin + Metronidazole + Omeprazole or Amoxicillin

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+ Clarithromycin + Omeprazole, or Clarithromycin + Methronidazole + Omeprazole for 14 days.[4] There are also studies that have shown the effectiveness of quadruple therapy regimens using bismuth salts.[7,8] However it is required to note that factors other than just the eradication rate of a regimen by itself are needed to be considered in choosing the best combination of drugs. Factors such as drug side effects, the patient's compliance regarding easy consumption of the drug, and even the cost of each regimen, all dwell in a paediatrician's mind, while deciding to choose a suitable combination of drugs for a specific patient.

In the previous study carried out by Dehghani et al, in our center at Shiraz University of Medical Sciences (Southern-Iran) in 2009 we evaluated the efficacy of the standard quadruple therapy compared to triple therapies of Omeprazole + Amoxicillin + Clarithromycin or Omeprazole + Amoxicillin-Clavulanic Acid + Metronidazole, and meanwhile discussed other factors which could have a crucial role in deciding how to prescribe the best regimen.[8] There we had reported a higher eradication rate of infection with the traditional quadruple therapy; therefore we suggested the latter regimen as the first line of therapy in our geographic region in southern Iran. On the other hand we had also pointed out that the quadruple regimen had the most side effects compared to the two alternative regimens, although it did not have any effects on the compliance of our patients regarding their intake of drugs, it still raises this question in mind that perhaps this regimen would not be the best choice for a specific patient. Maybe it would be wise to individualise each patient, and meanwhile take into consideration the parent's opinion on his or her child's treatment regimen. One might prefer a regimen with less side effects and higher cost, while the cost of a therapy might be the first consideration of another family. In this paper, as an extension to our previous research, we applied a decision making model to analyse the treatment options for eradication of H. pylori infection in children. The approach provides an excellent insight for making a safe decision,not only by considering the physician's point of view, but also by incorporating the parents and patient's idea (of course if he or she is old enough to reply) simultaneously. So, this is an extension for making a better solution and incorporates the parents and patients in making an integrated decision.

Method

In order to evaluate and assess the best known alternative according to multi-criteria and considering the decision maker's preferences, a multi-criteria decision making model entitled "Analytical Hierarchical Process" (AHP) is employed. The concept of the AHP is normally associated with pair-wise comparison of alternatives according to each criterion. Saaty[9] initially proposed the concept of AHP in 1980. After that in 1990 he developed his previous model demonstrating how to make an appropriate decision.[10] After that many researchers applied the AHP in different areas of science and technology.[11,12] Ordinarily while making a decision we have to consider many different criteria (and sometimes conflicting criteria), which cannot all be reflected simultaneously in a decision, so it is needed to prioritise each criterion. As a comprehensive review of the literature and applications of AHP in medical and healthcare systems we may refer to work done by Liberatore and Nydick in 2008.[13] Here, a General procedure of AHP is given below:

Step 1 – Organise hierarchical process including criteria and potential alternatives.

Step 2 – Set pair-wise comparison matrix according to criteria.

In order to make comparison much easier for an expert, pair-wise comparison is suggested. Each two alternatives therefore should be compared with each other according to a criterion. The results should be summarised through a matrix.

Step 3 – organise a normalise matrix (by dividing the individual elements by the total amount of each column).

The normalisation is performed due to the fact that the observations maybe reported in a set of small or large input data, therefore we would have to present the data with no scale. For making an integrated matrix, the data should be divided by the total summation of each column in order to present the percentage of that column. This process is called "normalisation".

Step 4 – Calculate the average for each row of pair-wise comparison matrix.

Step 5 – Multiply the results of step 4 in weight matrix.

Step 6 – Calculate the result of step 5 for each criterion.

Step 7 – Stop when the results are achieved (This procedure will stop when all criteria have passed step 6).

The hierarchical process of current research is given in Figure 1. The problem then is implemented in Expert Choice® software.

As it is shown there are four criteria (Comfort in drug consumption, side effects of the drugs, cost, and efficacy) for selecting the best alternative treatment among the three proposed regimes (Omeprazole + amoxicillin + Metronidazole + Bismuth vs Omeprazole + Amoxicillin +

Clarithromycin vs Omeprazole + Amoxicillin-Clavulanic Acid + Metronidazole). The goal is to select the best known alternative according to all of the criteria. Two of the criteria are qualitative (Comfort in drug consumption and side effect) and two of them are quantitative (Cost and Efficacy) parameters.

For going through this study, data gathering is conducted as given in Tables 1-5. The data filled up in the Tables 1 and 2 are derived according to the physician and parents judgments which implies qualitative pair-wise comparison of all regimes according to the comfort and side effect criteria. The data related to each table are put into a symmetric matrix. Therefore there is need for filling up half of the matrix. For example the term "extremely preferred" means that regime C is "extremely preferred" over the regime A according to the comfort criterion.

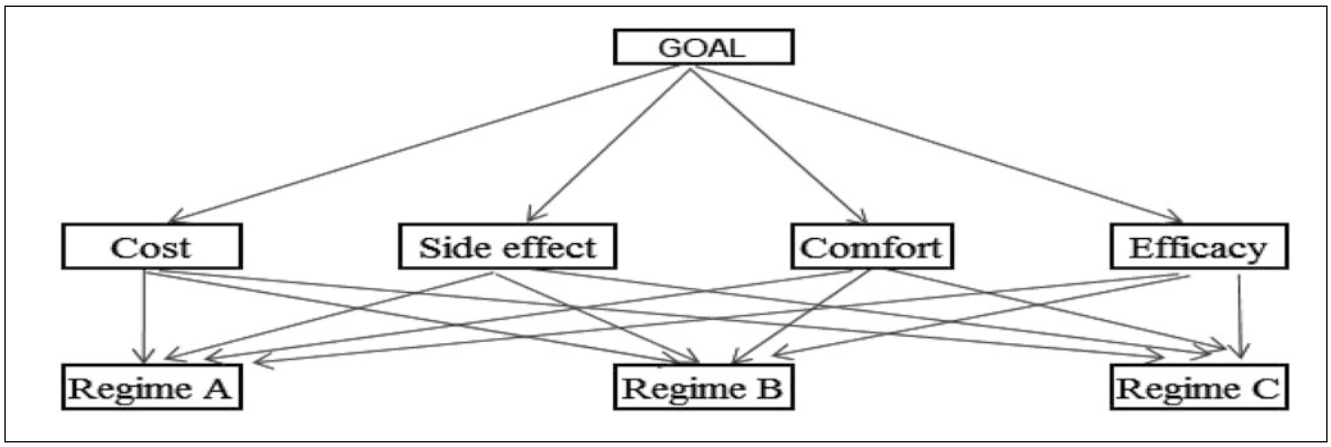

Figure 1 The hierarchical process of the problem.

Table 1 Pair-wise comparison of treatment regimes with respect to comfort

Comfort	Regime A	Regime B	Regime C
Regime A	–	Preferred	–
Regime B	–	–	–
Regime C	Extremely preferred	Highly preferred	–

Table 2 Pair-wise comparison of treatment regimes with respect to side effect

Side effect	Regime A	Regime B	Regime C
Regime A	–	–	–
Regime B	Preferred	–	–
Regime C	Highly preferred	Preferred	–

Table 3 Cost data of treatment regimes

Cost	USD
Regime A	5
Regime B	25
Regime C	12

Table 4 Efficacy of treatment regimes

Efficacy	
Regime A	91.9%
Regime B	82.1%
Regime C	80.5%

Table 5 Pair-wise comparison of criteria

	Comfort	Side effect	Cost	Efficacy
Comfort	–	Relatively preferred	–	–
Side effect	–	–	–	–
Cost	Preferred	Relatively preferred	–	–
Efficacy	Extremely preferred	Extremely preferred	Extremely preferred	–

The data can be expressed as preferred, extremely preferred or highly preferred which assigned a score equal to 5, 7 or 9 respectively. It is noted that dominant alternatives are presented. For converting qualitative factor to quantitative ones, bi-polar ordinal approach is applied. Data available in Tables 3 and 4 are exact data derived from the actual or pervious experiments.[8]

Here, an important focus should be made on the parent or patient's opinion upon the criteria preferences. Although the efficacy always plays an important role in making a decision, however, one should have a special attention to the "cost" or "comfort" criterion. Therefore if a physician does not have enough attention to the other affecting criteria, the patient may not consume the doctor's prescription. For example, in case of an expensive drug, a patient with a low economic status may not obtain the suggested prescription or in case of difficulties in consumption of the suggested drug (as for example capsules in small child), how could a patient follow the doctor's instruction. While, for example it would be possible to use a lower efficient regimen which is a less expensive alternative with a lower side effect and which can be easily consumed. Therefore, it is possible to put the parent or patient's opinion into a small size matrix by requesting him/her/them to tell you their preferences. In this respect within a few seconds, as shown in Table 5 as an example of a patient's opinion regarding the suggested criteria, the results can be achieved.

Generally, it is summarised that some criteria are related to patients (if they are old enough to reply appropriately to questions), some criteria are related to parents (for example cost of a drug), and also some criteria are just related to physicians (such as efficacy and side effect of a drug). It is also pointed out that in some cases; maybe more than one idea is included in respect to a criterion. For example, considering "comfort" the mother, father and the physician might have different ideas at the same time. On the other hand, maybe in some cases, it will be required to consider both the mother and the father's idea. This type of decision making is referred to as "group decision making". Group decision making is a type of decision making in which there is a need for including different ideas with different importance in order to make an integrated decision. This process is especially important for comparing the preference of the criteria which can be incorporated by the parents. Equation can be safety applied for group decision making.

$$G = (A^{WA} * B^{WB} * \ldots * Z^{WZ})^{1/(WA+WB+\cdots+WZ)}$$

In the above equation G indicates results of group decisions, A, B, ..., Z indicates individual pair-wise comparison for each decision maker. WA, WB, ... Also implies weight factor or the importance of decision maker's idea (point of view).

The expected result of different judgements can be found through calculation of the geometric mean. This mean can be calculated by weight (or importance) of each opinion. The weights; in case of un-equal importance of different decision makers, will be multiplied in the terms of calculation. An equal weight for all decision makers is also possible. Additionally, it is pointed out that a positive (efficacy) and a negative (cost of a drug) are both possible to consider. A mixture of opinions will become more important when criteria are compared to each other as it is presented in Table 5.

In Tables 1-5 input data are given which will encompass the procedure (step 2-6). Then, Figures 2-6 graphically demonstrate the solution provided by Expert Choice™ software.

After putting the data into the AHP model, the following results are obtained. The results are provided for individual criterion and then the overall scores are presented.

Result and Discussion

As it is demonstrated in our illustrative case, for selecting the best known alternative, an individual and equivalent analysis should be taken into account. As it is given in Figure 7, For example, regime A shows a good performance in efficacy while it has been associated with more side effects. On the other hand, regime C is a comfortable alternative while it is costly. The equivalent analysis shows that regime A is the best alternative according to data and the criteria used. On the other hand, in priority regime C is better than regime B. However; the preference of regime A over regime C is not dominant, since the score of both is in close proximity to each other. This system works as a decision support system for making the best choice. When the difference among alternatives is marginal, a sensitivity analysis can be conducted. In this case, input data may slightly change and the results can be obtained again. However, it is open to the parents or the patient to make the final decision regarding to selection of the best regime. As a validation rule in AHP based approaches, the inconsistency index should be less than 0.1 in order to prove that no conflict has been raised during the expert judgment process. In this paper, the software presented an acceptable index for the

Figure 2 Derived priorities with respect to side effects.

Figure 3 Derived priorities with respect to cost.

Figure 4 Derived priorities with respect to efficacy.

Figure 5 Derived priorities with respect to goal.

Figure 6 Derived priorities with respect to alternatives.

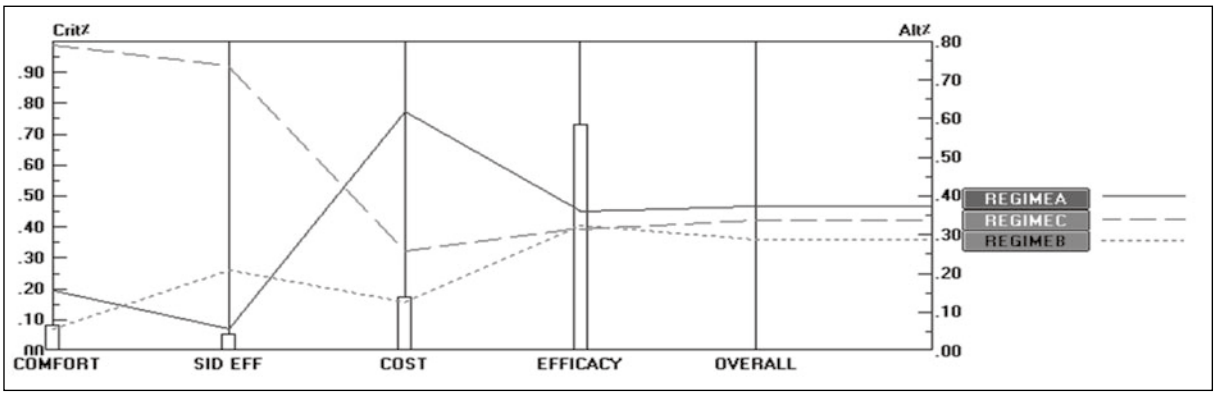

Figure 7 Overall efficacy of the treatment regimes.

data observed. Therefore, it means that the obtained results are robust for making the final decision. As a need, it is required to apply commercial computer packages for solving AHP problems such as Expert Choice® or it is also possible to develop a user friendly computer program for quickly running of AHP cases. Also the general concept of group decision making and the basic idea of AHP should be trained. This approach will certainly enhance the quality of decisions to be made by physicians and will make a utility for patients/ parents which were incorporated through the decision making process.

Conclusion and Further Recommendation

Regime selection is normally done according to the efficacy of a regime on the patient. It is generally selected by the physician and of course it is different from one to another. However, the patient can be involved in the prescription of his/her regime. By this approach multi criteria decision making analysis can be adapted to include both qualitative and quantitative criteria and their effects on the goal. The qualitative conditions can be obtained through the patient's judgements as well. Finally the best alternative should be selected according to aggregation of all criteria on the alternatives provided. The approach applied a group decision making process which incorporates parents/patients in the decision making process.

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