Main Title

MULTI-CRITERIA DECISION MAKING IN HEALTH CARE USING AHP AND MICROSOFT EXCEL

Running Head

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MULTI-CRITERIA DECISION MAKING IN HEALTH CARE USING AHP AND MICROSOFT EXCEL

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method developed by Saaty[1] in the 1970s. Its purpose is to help decision-makers choose the best solution in complex situations that require the evaluation of different alternatives based on conflicting criteria.

This method has been used in a wide variety of business decisions and it has been recently implemented in the healthcare industry.[2] Decision situations to which the AHP can be applied in the healthcare industry include: diagnosis, patient participation,[3,4] therapy/treatment, organ transplantation, evaluation and selection of projects, medical technology and human resource planning, and evaluation of health care facilities.

The AHP methodology consists of 3 stages. The first one represents the problem through a hierarchy of multileveled decision items. The second stage compares the various elements of one hierarchical level to one another two at a time, with respect to their impact on an element above them in the hierarchy. These pairwise comparisons will produce the weight (priority) of each element of the hierarchy. Lastly, in the third stage, weights are synthesized to obtain the final score of each alternative. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process.[5]

Since the purpose of this brief report is not the methodology itself, but its implementation in a spreadsheet, the reader interested in a deeper knowledge of the methodology is referred to two papers available online from professors Thomas L. Saaty[5] and Ernest H. Forman.[6]

The unique advantages of the AHP can facilitate the decision making process in the healthcare industry. On the one hand, it simplifies complex problems because it prevents users from making uninformed or intuitive decisions. On the other hand, it's a simple yet effective methodology. Besides, its flexibility allows users to customize the process according to their preferences, and it provides information about the consistency of the pairwise judgments.

In order to facilitate the application of this methodology to the medical decision-making process, a generic spreadsheet in Microsoft Excel 2007 (AHPDM.xlsm) was developed; this spreadsheet can be downloaded for free from the Medical Decision Making webpage. Its main advantage over the other free computer-based tools that facilitate AHP analyses is its ability to perform all the steps of the decision making process using a simple and transparent procedure that shows all the calculations and allows users to customize the process according to their needs. Specifically, the tool 123ahp (http://123ahp.com) does not explain how priorities are synthetized and does not warn that judgment inconsistencies may occur, and MakeItRational (http://makeitrational.com) does not provide the value of the consistency ratio, although the application warns that judgment inconsistencies may occur. Finally, the AHP Excel template available at http://bpmsg.com/category/ahp/ does not include the hierarchy of the decision problem and the final aggregation of weights to obtain the best alternative, and the BPMSG AHP Online System (http://bpmsg.com/academic/ahp-hierarchy.php) does not explain how priorities are synthetized

Along with this spreadsheet, we provide another one (AHPexample.xlsm). This additional spreadsheet is a tutorial that exemplifies the shared decision-making process for the best treatment for early-stage breast cancer. The data we used to carry out the procedure comes from the treatment guide for breast cancer published by the Andalusian Health Department (Spain).[7]

The protocol contained in the spreadsheet AHPDM.xlsm, can be divided into three different stages: creation of the model, comparison, and synthesis. Each phase of the protocol, which has been validated using Expert Choice® (a commercially available AHP software program), is presented on a separate worksheet, along with a quick start guide and bibliography.

The weight of each element of the hierarchy was calculated using a variation of the original eigenvector approach called "Averaging over the normalized columns", described by Saaty[1] as a good approximation. However, we should not forget that this approximation can lead to rank reversal in spite of the closeness of the result to the eigenvector.[8] Likewise, we used the distributive synthesis mode to calculate the final score of each alternative. Although the ideal mode has been widely used as well, we chose the distributive synthesis mode because:[9] 1) The alternatives that have not been chosen can be relevant for the decision maker, and 2) It has been widely demonstrated that there are no significant differences between the results produced by the two synthesis modes (see comparison table in AHPexample.xlsx). Despite the advantages of the distributive synthesis method, we should remember that in the distributive mode the introduction or removal of any alternative (relevant or irrelevant) may affect the ranking or ratios of existing alternatives.[9]

Step 1. Model the problem as a hierarchy

The user must represent the model in a hierarchical format taking into account that it is limited to 7 criteria and 5 alternatives, according to the limits established by Miller.[10] In order to achieve this goal, the user must insert the following information into the yellow (highlighted) cells of the worksheet called STEP 1 HIERARCHY (the data from the example is displayed in brackets):

1. The goal of the problem (to choose the best treatment for early-stage breast cancer).
2. The names of the different criteria. (Breast Look, Radiation Therapy, Reconstructive Surgery, Local Reappearance).
3. The denomination of each alternative (Conserving Surgery, Mastectomy).
4. Patient's name (Mary Smith).
5. Date (20/02/2014).

Step 2. Comparisons

In this stage, which consists of two separate steps, the elements of one hierarchical level are pairwise compared to their impact on the element in the previous level.

Step 2.1. Criteria comparisons

This phase is presented in the worksheet titled STEP 2.1 CRITERIA COMPARISON. In this worksheet, the user must perform pairwise comparisons of each criterion with respect to its importance for reaching the goal. When doing these comparisons, the user must utilize a nine point scale to fill data into the yellow cells of the Subjective Judgment table. In our example, the first criterion, Breast Look, is compared to the second, Radiation Therapy, indicating which one is more important and to what extent. In this example, if we consider that Breast Look (Criteria A) is slightly more important that Radiation Therapy (Criteria B), we must place *A* as the more important criterion and *3* as the intensity of this dominance, based on the table values provided by the nine point scale for pairwise comparisons. Afterwards, we continue comparing each criterion against the others until all yellow cells are completed. (Figure 1).

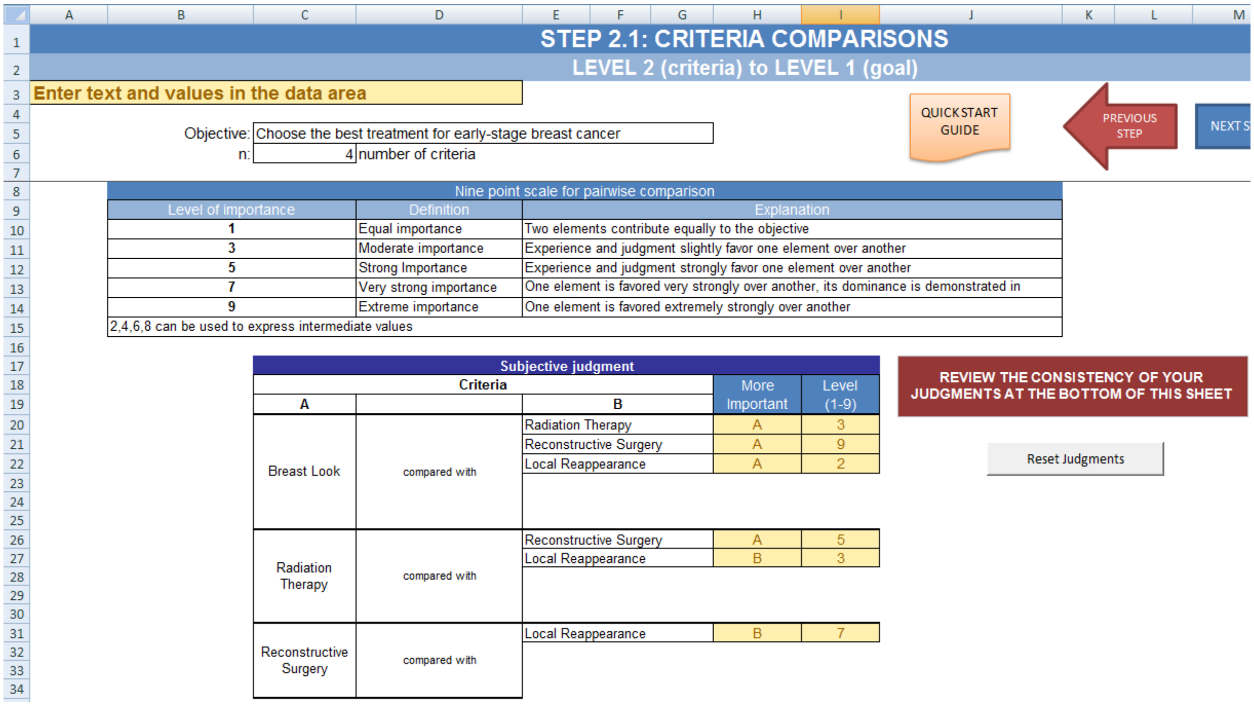

Figure 1. Criteria comparisons

Once all values have been entered into the table, the excel worksheet automatically calculates the pairwise comparisons matrix and normalized matrix. Through this intermediate step we will obtain the weight (priority) and consistency of each criterion.

The table produces weight values associated with Breast Look (0.479), Radiation Therapy (0.158), Reconstructive Surgery (0.043), and Local Reappearance (0.320) (due to the approximation we used, the weights are different from those calculated by the original eigenvector approach by 0,416%, 1,935%, 2,381% and 0,929% respectively, but the rank is the same). Based on these results, it can be concluded that Breast Look is the most highly valued criterion.

In addition, the worksheet provides the consistency of each criterion. Under ideal circumstances, the consistency of each criterion should equal the number of elements compared (in our example, this number is 4). Since this is not the usual case, the worksheet also determines the consistency ratio. If the value of the consistency ratio is less than or equal to 0.1,[5] cell C87 shows the result of consistent comparisons. If the consistency ratio is greater than 0.1, cell C87 shows that the comparisons are inconsistent; therefore, the user needs to review the judgments in the Subjective Judgment table.

Step 2.2. Alternatives comparisons

This step is presented in the worksheet titled STEP 2.2 ALTERNATIVES COMPARISON. In our example, there are two equally valid surgical alternatives: Conserving Surgery and Mastectomy.

The user must follow the procedure described in the previous step. This procedure consists of a series of comparisons or "which do you prefer" between each of the different alternatives with respect to its impact on each criterion. To that end, the user must fill in the yellow cells related to each criterion in the Subjective Judgment tables (using a nine point scale for pairwise comparison). After that, the user must test the weights and consistency of each alternative.

Once more, the consistency of each alternative must be equal to the number of elements compared (in our example, this number is 2). The comparison of only two elements produces the ideal consistency level; therefore, it is not necessary to calculate consistency ratios. However, when the number of alternatives in the model is greater than 2, the worksheet displays this value and it determines whether the comparisons are consistent or inconsistent. If the comparisons are inconsistent, the user must review the judgments contained in the Subjective Judgment tables until consistency among all comparisons is achieved.

Step 3. Results

This step, which provides the user with the final score of each alternative, is shown in the worksheet labeled STEP 3 RESULTS. In addition, this worksheet shows a ranking of the different alternatives analyzed and identifies the best one. In our example, the conservative treatment method (Conserving Surgery, final value: 0.569) would be the best option for the patient (Figure 2).

However, if the user utilized inconsistent judgments and these were not corrected, the optimal choice will be displayed along with a warning indicating whether the inconsistency value was produced in the comparisons among the criteria, the alternatives, or both.

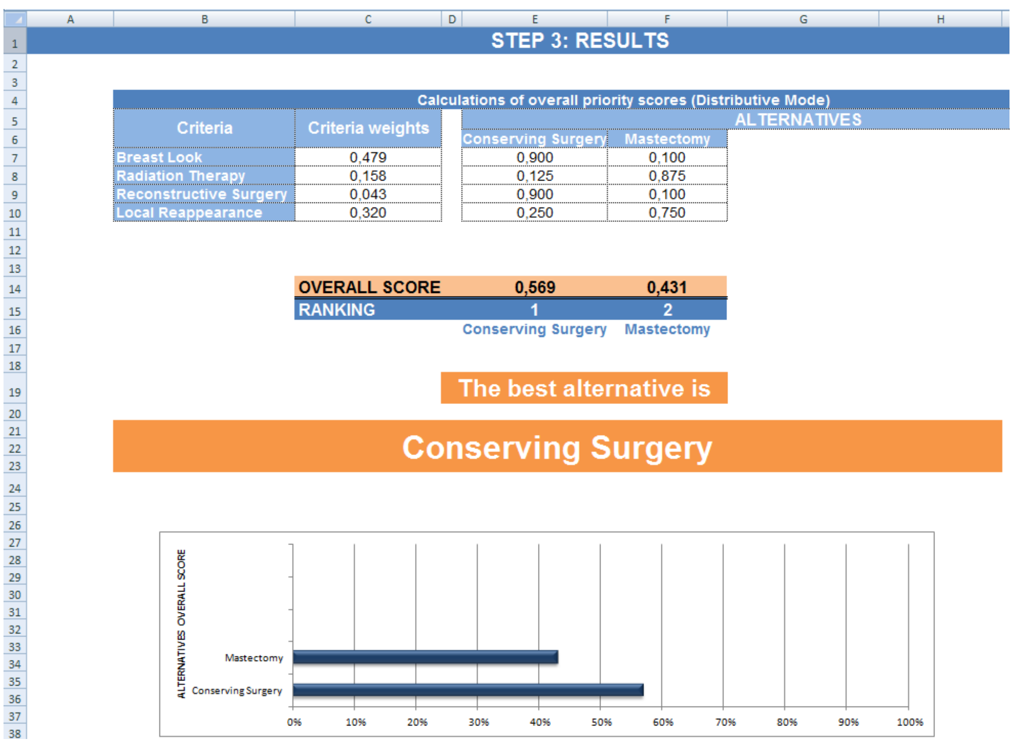

Figure 2. Results

References

1. Saaty TL. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York: McGraw-Hill; 1980.
2. Liberatore MJ and Nydick RL. The analytic hierarchy process in medical and health care decision making: A literature review. European Journal of Operational Research. 2008;189(1):194–207.
3. Dolan J. Shared decision-making—transferring research into practice: the analytic hierarchy process (AHP). Patient Educ Counsel. 2008;73:418–25.
4. Dolan JG, Boohaker E, Allison J, Imperiale TF. Patients' preferences and priorities regarding colorectal cancer screening. Med Decis Making. 2013;33(1):59-70.
5. Saaty TL. The analytic hierarchy process—what it is and how it is used. Mathematical Modelling. 1987; 9 (3–5):161–176. http://www.sciencedirect.com/science/article/pii/0270025587904738. Accessed 20 February 2014.
6. Forman EH, Gass SI. The analytic hierarchy process—an exposition. 2013. http://professorforman.com/ahpexpo.pdf. Accessed 20 February 2014.
7. Junta de Andalucía. Alternativas de tratamiento para el cáncer de mama. ¿Qué opción prefiero? Instrumentos de Ayuda para la Toma de Decisiones. Granada: Dirección General de Calidad, Investigación y Gestión del Conocimiento. Consejería de Salud de la Junta de Andalucía; 2006.
8. Saaty TL and Vargas LG. Experiments on rank preservation and reversal in relative measurement. Mathematical and Computer Modelling. 1993;17(4–5):13–18.
9. Forman EH, Gass SI. The analytic hierarchy process—an exposition. Operations Res. 2001;49:469-86.
10. Miller GA. The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. Psychol Rev. 1956;63:81-97.

Notes

- The two files are compatible with Microsoft Excel 2007 and above.
- The worksheets contained in the AHPDM.xlsm file are blocked; data can only be entered into the highlighted cells. As a consequence, the user cannot accidentally erase any formulas and alter the results produced.
- Users interested in learning the AHP methodology and formulas used can remove the protections (no password is required) for each worksheet using the Review->Unprotect Sheet command for Microsoft Excel 2007 and above. For a greater level of detail of the procedures used for each calculation, intermediate calculations are displayed in light grey.
- When the file is opened for the first time in Microsoft Excel 2007, it generates the error "A formula in this worksheet contains one or more invalid references. Verify that your formulas contain a valid path, worksheet, range name, and cell reference" due to the incorporation of a dynamic chart in the STEP 2.1 CRITERIA COMPARISON worksheet. This error has been documented by Microsoft (http://support.microsoft.com/kb/931389/en-us) and is not relevant; it will disappear when the user inputs data.
- This spreadsheet use VBA macros to represent the hierarchy. Excel will not run macros by default, so you'll have to explicitly change some settings in order for any macro to run automatically on start up. For Excel 2007 launch the program and click "Office Botton | Excel

Options | Trust Center | Trust Center Settings | Macro Settings." You must select "Enable all macros (not recommended, potentially dangerous code can run)." Click "Ok" and macros will be enabled.

For Excel 2010 launch the program and click "File | Options | Trust Center | Trust Center Settings | Macro Settings." You must select "Enable all macros (not recommended, potentially dangerous code can run)." Click "Ok" and macros will be enabled.