Management in health
XXVII/2/2023; pp. 15-19

MODELING THE DECISIONS REGARDING ONCOLOGICAL PRACTICE UNDER UNCERTAINTY CONDITIONS

Oliver Daniel SCHREINER, *PhD student, Regional Institute of Oncology, Iasi, România*

Marius PÎSLARU*, *Prof. dr. ing., Management Dept., Technical University "Gheorghe Asachi", Iasi, România*

Valentin BEJAN, *Asistent Ph.D, Department of Surgery, Saint Spiridon County Hospital, Iași, România*

**Corresponding author*
Marius Pislaru, Universitatea Tehnică „Gheorghe Asachi" din Iași, Bulevardul Profesor Dimitrie Mangeron 67, Iași 700050, marius.pislaru@academic.tuiasi.ro, 0740208953*

BACKGROUND: *The existence of multiple decision criteria is due to a variety of cancer types, health systems, treatments, options and individual factors, a multitude of different criteria that can be considered in the routine clinical decision in oncology.*

THE METHOD USED: *The decision under conditions of uncertainty corresponds to the case where the probabilities of achieving the states of the objective factors are not known, which can be not only natural factors (medical, related to the patient's state of health), but also economic, social, political factors (government cancer policy, law enforcement, treatment regulation, risk groups, interest groups, etc.), to the extent that they are not controllable by the decision maker. Among the analysis models under conditions of uncertainty, the Weighted Optimism Criterion (Hurwicz) was chosen, based on which a coefficient is defined that shows how optimistic or pessimistic the decision-maker is.*

RESULTS: *The model allows a sensitivity analysis of the solution by the changing of the value of the optimism index, which makes the analysis of decisions under conditions of uncertainty applicable to a large number of patients from different socio-economic backgrounds and with different temperaments (which can be influenced by age and/or gender). The optimistic patient is more concerned with Treatment Compliance, i.e. long-term survival, and the pessimistic patient is also majorly concerned with Treatment Compliance, but he/she also becomes concerned with "treatment toxicity", so short-term effects. Regardless of the degree of optimism, the second place in the patient's concern is the institution's performance and the doctor's experience, which thus become determining factors - directly related to the level of trust, regardless of the type of patient.*

CONCLUSIONS: *The analysis of the way of making decisions under conditions of uncertainty is relevant for the strategy of approaching the decision made through the doctor-patient agreement.*

Keywords: *Decision modeling, Oncological practice, Uncertainty conditions, Weighted Optimism Criterion (Hurwicz).*

INTRODUCTION

The clinical decision-making process is the essence of everyday clinical practice. Different factors influence clinical judgments and decisions. Several options may be available for decisions in the case of oncological problems, related to: individual characteristics of the decision makers, characteristics specific to the decision, and contextual factors (the environment in which the decision is made). Medical decision-making can be particularly complex and multi-layered, involving diagnoses and therapeutic uncertainties, patient preferences, and the complexity of medical care or the environment. Many decisions made in oncology are not based solely on evidence-based medicine, that is related to clinical experience and the best available research for the particular case study. Therefore, decision-making based on eminence, representing the opinion of an experienced colleague - for example, can be decisive. Furthermore, decision making in medicine ideally involves the patient and thus can be characterized as shared decision making. The existence of multiple decision criteria is due to a variety of cancer types, health systems, treatments, options and individual factors, a multitude of different criteria that are considered in the routine clinical decision in oncology. This has been demonstrated in decision analyzes of clinical experts, [1-3].

The elements of a decision problem determine how to approach the decision, which are: the decision-maker, the goal, the alternatives, the assessment criteria, the restrictions of the problem and the states of nature, [4].

1. The decision-maker is the person, or group of people, who choose the alternative considered the best. As he/she is, or is not, the one who assumes the responsibility of the choice, a distinction can be made between the decision-maker as a specialist/doctor or as a patient. According to the number of people who decide on a problem, individual decisions are distinguished, respectively collective, or group decisions, if we are dealing with a case involving several medical specialties.

2. The goal pursued by the decision-maker or the objective of the decision represents the very rationale of the decision -making process. It is the expectation horizon of the one who makes the decision, the performance he/she wants to obtain following the implementation of the decision taken.

3. The alternatives, or variants, are the solutions available to the decision-maker, from which he/she must choose the optimal one. Depending on the number of alternatives, decision problems can support several types of classifications, in our case under conditions of risk, or uncertainty.

4. The assessment criteria. The goal pursued by the decision-maker can be embodied in one or more criteria, with the help of which medical alternatives are compared with each other, in order to choose the best one. If the goal can be materialized in a single criterion, one-criteria or one-dimensional decisions are reached. But it is obvious that, on the one hand, treating all problems as one-dimensional is at least simplistic, and on the other hand, it is not always possible to determine the value of that single criterion that allows the choice, so that, instead of it, more quantifiable criteria are necessary. In the presented case, it is about multi-criteria or multi-dimensional decisions, many assessment criteria being either independent of each other and/or contradictory.

5. The restrictions of the problem are limitations of the field of admissible solutions, obtained by means of assessment criteria, whose minimum or maximum limits are

imposed by objective or subjective considerations. For example, risk factors and comorbidities specific to certain age groups or conditions unrelated to the subject of oncological disease, and above all, the existence of rigid, standardized clinical practice guidelines, are obvious restrictions. Another important factor is the term of medical recovery and it represents a criterion for evaluating the variants and its minimum value may indicate the optimal variant. Many decision-makers impose that the recovery period does not exceed a certain value, so that any option that has a recovery period longer than the imposed one is not taken into account, even if from other points of view, it seems tempting. The cost of the treatment must also be reasonable, so that it can be accepted, but many times, the options that exceed the available amount cannot even be considered, even if the optimal option can be found among them. The selection of patients may impose subjective restrictions, and to facilitate the selection process, these restrictions may eliminate patients who are a priori eligible for a certain treatment scheme. These considerations argue for the use of the smallest possible number of restrictions in the decision-making process, in order to allow a correct selection of the variants. It is recommended that the restrictions of the problem be taken into account only after the ranking of the variants has been drawn up.

6. The states of nature represent the totality of the objective factors that can change the outcome of the choice, independently of the decision-maker. The objective factors (or disturbances) are not only natural (medical) factors, but also economic, social, political factors etc., to the extent that they are not controllable by the decision maker.

7. Time represents an element of the decision problem with several meanings. A first meaning has in mind the period of time to which the decision taken refers. From this point of view, we can talk about short-, medium- and long-term decisions, which can be associated with the levels of medical impact. Another influence of time in decision problems leads to their division into static (timeless) decisions, in which it is a single choice, at a moment in the medical process (for example the decision to undergo chemotherapy or radio-therapy) and dynamic (sequential) decisions that consist of a sequence of decisions, which flow from one another and which are analyzed as a decision-making ensemble, in connection with the progress of the disease and the evolution of the patient.

In order to make the optimal decision, it is necessary to take into account:

1. Identifying all possible alternatives or options, that is, the ways in which the decision-maker can act.

2. Identifying the possible states of nature so that these events are mutually exclusive.

3. Evaluation of the results of the choice of any variant in any of the states of nature. These evaluations or results also represent treatment costs and can be presented in the form of tables or matrices.

If the decision-maker has no information on the probability of occurrence of any of the states of nature, but can evaluate the results of choosing each alternative in all states of nature, it is said that decisions are adopted under conditions of uncertainty.

Decision under uncertainty is one of the main areas of research in decision theory, due to its numerous applications, including in medical diagnosis. The decision in conditions of uncertainty correspond to the case where the probabilities of achieving the states of the objective factors are not known, which can be not only natural factors (medical, related to the patient's state of health), but also economic, social, political factors (government policy for cancer, law enforcement, treatment settlement, risk groups, interest groups, etc.), to the extent that they are not controllable by the decision-maker.

In the case of a lack of information regarding the factors or events that can influence the results of the choice of options, an important role is played by psychological factors and medical experience. The decision will largely depend on the subjective reasoning of the decision-maker, on the fact that he/she is a specialized person. In the conditions where the decision is taken by mutual doctor-patient consultation, the decision will largely depend on the subjective reasoning of the patient decision-maker, on the fact that he/she is an optimistic or pessimistic person.

METHOD

The decision-making process is very complex. The variable weights of the criteria and the aggregation of the different rules lead to a multitude of possible interpretations and clinical implications, [5]. Also, the impact of each of the categories of decision criteria varies and there are also interactions between these categories. Such criteria may be related to the decision-making factors (e.g. disease-related symptoms, biomarkers, laboratory values, morphological/histological characteristics of cancer, tumor stage, ”treatment toxicity”, ”time margin” etc.), specific decision criteria (institutional performance, doctor's experience, treatment compliance etc.), or contextual factors (recent clinical studies, access to resources/information, government policies, refund policies/costs etc.). On the other hand, specific factors may be identified, e.g.: life quality, patient motivation/adherence to treatment, age, gender, comorbidities, emotional stress, patient socio-economic status/financial situation, culture/religion, family influences/support groups etc., [6-9].

For the case study, among all the analysis models under conditions of uncertainty, the Weighted Optimism Criterion (Hurwicz) was chosen.

For the analysis of this method, we assume that the Decision Criteria are C_i, with i = 1, n and the Factors – the restrictions N_j, j = 1, m , then the result of the choice of Criterion C_i in the state of nature F_j is denoted R_{ij} and represents an estimator of the decision regarding the treatment. These data are presented in tabular form, Table 1, [4].

Table 1. Criterion analysis

Criteria/ Factors	F_1	F_2		.....F_j...	F_m
C_1	R_{11}	R_{12}		.....	R_{1m}
C_2	R_{21}	....		.....	R_{2m}
....C_i...	.....	.....		...R_{ij}...	.....
C_n	R_{n1}	.....		.....	R_{nm}

Table 2. Analysis of the relevance of the criteria

Criteria / Factors	Age	Gender	Co-morbidities	Motivation/ Adherence to treatment	Socio-economic status	Culture/ religion	Emotional stress	Family influence	*Total Index/ Criterion*
Disease-related symptoms	3	2	9	6	7	7	9	7	**50**
Biomarkers, laboratory values Morphologic/histologic characteristics of cancer	8	5	9	1	1	1	4	1	30
The doctor's experience	7	7	1	9	7	2	9	9	**51**
Tumor stage	8	5	2	9	2	2	9	6	43
Treatment compliance	9	9	9	9	1	1	1	1	40
Treatment toxicity	9	7	10	8	2	1	9	1	47
Time margin	9	2	7	10	9	2	9	7	55
Institutional performance	1	1	8	9	9	2	9	9	48
Refund policies/costs	5	5	1	6	9	1	9	8	44
Total Index / Factor	59	43	66	65	47	18	**68**	49	-

Within the criterion of weighted optimism (Hurwicz), a coefficient is defined as the fractional number that shows how optimistic or pessimistic the decision-maker is. This coefficient is equal to 1 for the exaggerated optimist and 0 for the exaggerated pessimist. As a result, it can be said that this criterion is applicable to decision-makers in a state of uncertainty, due to the conditions that describe the complexity of the problems present in oncology. So, optimism is expressed by the optimism index, $\alpha \in (0,1)$, so that $(1-\alpha)$ is the pessimism index. The choice of the coefficient depends on the decision maker.

With this coefficient, a weighted average of the R_{ij} result is determined, according to the relationship:

$p_i = \alpha \max R_{ij} + (1-\alpha) \min R_{ij}$, for each Criterion i.

The final decision should correspond to the estimated P value: $P = \max p_i$

Not always the P value is very relevant, or it may give an incomplete picture. The medical picture can be expanded in terms of precision when values of the degree of verisimilitude of the occurrence of a certain state of nature can also be entered. Examples of values of the degree of verisimilitude: Impossible 0; Improbable 0,01 – 0,05; Doubtful 0,06 – 0,25; Plausible 0,26 – 0,45; Posible: 0,46 – 0,55; Likely 0,56 – 0,75; Very likely 0,76 – 0,95; Almost sure 0,96 – 0,99; Sure 1. In this case, medical or psychological aspects that either cannot be specified with accuracy, are either not relevant in the respective medical field, or did not lead to relevant clinical results, can be ignored. In the end, the alternative with the highest value will be chosen.

When probabilities are imprecise, the exact probability value that a random variable can take is unknown, but a probability interval in which it is included can be known. The estimation of the probabilities of occurrence of the states of nature can be subjective, however, because it depends on the decision-maker, therefore on psychological factors, intuition, experience, as well as on the quantitative and qualitative information possible to obtain through tests and medical analyses. Such a probability, called a priori or subjective probability, is not determined based on calculations, but is based on the intuition of the decision-makers, on their experience regarding the results obtained in similar clinical conditions. Regardless of the way of establishing the value of the probabilities, for the choice of the optimal therapeutic option, the expected value will be calculated for each criterion considered, for which the probability values are given as weights of the clinical incident factor – the medical restrictions (here – the states of nature). To help overcome uncertainty, the option with the highest desirability or expected value, otherwise known as "expected utility," should be used.

Initially, we start with a single value for p_i, for a maximum value of the optimism index

$\alpha = 1$, and a preliminary analysis is made of the relevance of the criteria based on the expected value. In the second stage, values are assigned to the parameter - optimism index $\alpha \in (0,1)$, in order to calculate the weighted average of the result R_{ij}, so that in the end we obtain p_i for each Criterion i, respectively the estimated value $P = \max p_i$ which will lead us to the final decision on the value of the criteria.

The working method also allows a sensitivity analysis of the solution to the change in the value of the optimism index, which makes it applicable to a large number of patients from different socio-economic backgrounds and with different temperaments (which can also be based on age and sex).

RESULTS AND DISCUSSION

Preliminary analysis of the relevance of the criteria is related to the medical context. The factors are specific to the socio-economic environment and the patient's temperament. For each R_{ij}, a scale of relevance/direct correlation values between criteria and factors is assigned, which can take values from 1 to 10, and which results from the maximum value of 10 multiplied by the values of the degree of verisimilitude, described as above. The results are presented in Table 2.

A first finding is that the maximum index vs. criteria can be found at: The time margin, followed by: The experience of the doctor and Symptoms related to the disease, but in which clearly the subjective influences related to: Socio-economic status, Culture/religion, Emotional

Table 3. Criteria values for optimistic patient and for moderately pessimistic patient

Criteria	p_i factor optimistic patient	p_i factor moderately pessimistic patient
Disease-related symptoms	7.6	4.8
Biomarkers. laboratory values Morphological/histological characteristics of cancer	7.4	4.2
The doctor's experience	7.6	4.2
Tumor stage	7.6	4.8
Treatment compliance	7.4	4.2
Treatment toxicity	8.2	4.6
Time margin	8.4	5.2
Institutional performance	7.4	4.2
Refund policies/costs	7,4	4,2

A more in-depth analysis can be done if what we mentioned above is taken into account, i.e. if medical or psychological aspects are ignored, if considered not relevant from the perspective of a criterion, and therefore could be eliminated from the analysis. That is why we propose a different type of analysis than the classical one, namely if the analysis is considered only by accounting the degree of verisimilitude from "possible" to "certain" (values in the table from 5 to 10), and the average of the factors is made, and not their sum, as in classical procedure. The following table results, Table 4.

It can be seen that the analysis of average index vs. criteria led to a high relevance of: Compliance of the treatment, followed by: Performance of the institution and Toxicity of the treatment, without having subjective influences. Regarding the average index vs. factor, we note the great relevance, which is certified once again, of Emotional Stress, followed by Comorbidities and Motivation/ Adherence to treatment, without having subjective influences. Here it can be seen that gender, culture and family influence cannot play a major role in the patient's decision.

Table 4. Optimised analysis of the relevance of the criteria

Criteria / Factors	Age	Gender	Co-morbidities	Motivation/ Adherence to treatment	Socio-economic status	Culture/ religion	Emotional stress	Family influence	*Total Index / Criterion*
Disease-related symptoms	3	2	**9**	**6**	**7**	**7**	**9**	**7**	**7.5**
Biomarkers, laboratory values Morphologic/histologic chracteristics of cancer	**8**	**5**	**9**	1	1	1	4	1	**7.33**
The doctor's experience	**7**	**7**	1	**9**	**7**	2	**9**	**9**	**8.2**
Tumor stage	**8**	5	2	**9**	2	2	**9**	**6**	**8.25**
Treatment compliance	**9**	**9**	**9**	**9**	1	1	1	1	**9**
Treatment toxicity	**9**	**7**	**10**	**8**	2	1	**9**	1	**8.6**
Time margin	**9**	2	**7**	**10**	**9**	2	**9**	**7**	**8.5**
Institutional performance	1	1	**8**	**9**	**9**	2	**9**	**9**	**8.8**
Refund policies/costs	**5**	**5**	1	**6**	**9**	1	**9**	**8**	**7**
Total Index / Factor	**7.85**	**6.6**	**8.67**	**8.13**	**8.02**	**7**	**9**	**7.67**	-

stress, and Influences of the patient's family play an important role. Regarding the maximum index vs. factor, we note the high relevance of Emotional Stress, followed by Comorbidities and Motivation/Adherence to treatment, but where the objective influences are clearly related to: Toxicity of the treatment, Time Margin, but also to the Institution's Performance and the Doctor's Experience.

The final decisions on the values of the criteria for optimistic patient, $\alpha = 0.8$, as well as for moderately pessimistic patient, $\alpha = 0.4$, are presented in Table 3.

P = 8.2 – "Treatment toxicity" has the maximum relevance in conditions of uncertainty for optimistic patient.

P = 5.2 – "Time margin" presents the maximum relevance in conditions of uncertainty for moderately pessimistic patient.

The optimistic patient is more concerned with the toxicity of the treatment, i.e. with long-term survival, and the pessimistic patient is more concerned with short-term survival/ case resolution, actually wanting an immediate solution.

As a first conclusion, the choice of the patient is made according to the adequacy of the treatment and the reputation of the oncological institution, and the decision on the treatment approach is made in relation to the patient's physical state - comorbidities and his mental state - the degree of emotional stress.

The final decisions on the optimized values of the criteria for optimistic patient, $\alpha = 0.8$, respectively for moderately pessimistic patient, $\alpha = 0.4$, are presented in Table 5.

P = 8.8 – "Treatment compliance" presents the maximum relevance in conditions of uncertainty for the optimistic patient, but the importance of the institution's performance and the doctor's experience is also noted.

P = 9 – "Treatment compliance" offers the maximum relevance in conditions of uncertainty for the optimistic patient too, but the toxicity of the treatment and the insti1ution's performance are also noteworthy.

Table 5. Optimised criteria values for optimistic patient and for moderately pessimistic patient

Criteria	p_i factor optimistic patient	p_i factor moderately pessimistic patient
Disease-related symptoms	8.4	4.8
Biomarkers, laboratory values Morphological/histological characteristics of cancer	8.2	4.2
The doctor's experience	**8.6**	4.2
Tumor stage	8.4	4.8
Treatment compliance	**8.8**	4.2
Treatment toxicity	8.2	4.6
Time margin	8.4	5.2
Institutional performance	**8.6**	4.2
Refund policies/costs	8.2	4.2

A first observation is related to the fact that regardless of the degree of optimism, the p_i values are much closer according to the new method of analysis, which in our opinion leads to more relevant interpretations, without having subjective influences.

The optimistic patient is more concerned with the Compliance of the treatment, related to the long-term survival, and the pessimistic patient is also majorly concerned with the Compliance of the treatment, but also being concerned with the toxicity of the treatment - the short-term effects.

Regardless of the degree of optimism of patient, the second place of concern is given by the performance of the institution and the experience of the doctor, which thus become determining factors, regardless of the type of patient.

CONCLUSIONS

The study carried out for the analysis of the way of making decisions under conditions of uncertainty is relevant for the strategy of approaching the decision made by doctor-patient agreement. Even if the objective and subjective influences on the decision are taken by quantifying factors based on the verisimilitude of the impact on the decision, it was found that there are stable criteria regardless of age, gender, etc. of the patient and above all, that there are certain criteria independent of the degree of optimism of patient taken into account, extremely important aspects in the doctor-patient relationship (the decision is easy if the patient considers that he/she has arrived at the optimal oncology institute, that he/she trusts the doctor's experience and that he is willing to accept the treatment - considered - by common agreement - according to the stage of the respective disease).

As can be seen, the decision under uncertainty presents a nuanced interpretation:

- in the case of the classic analysis based on the expected value, this does not have a direct impact on the treatment itself, but impacts the decision at the level of the doctor-patient relationship, in the conditions where the decision on the treatment is taken by mutual agreement. There is clearly an influence of socio-economic factors in the patient's decision. At this stage, it is obvious that the doctor has a feedback on the psychological approach, more than on the actual clinical action, which he/she will address after the decision-making analysis under risk conditions.

- in the case of the proposed new method of analysis, the direct impact on the importance of the treatment itself can be observed, which, even if it impacts the decision at the level of the doctor-patient relationship, more precisely justifies the option of the patient. The patient, regardless of his/her degree of optimism, is constantly concerned on the compliance and the toxicity of the treatment. Here, the performance of the institution and the experience of the doctor can give a greater consistency to the decision on the treatment, which is taken by mutual agreement.

References

1. Vettese, E. et al. Symptom management care pathway adaptation process and specific adaptation decisions, BMC Cancer, 2023, 23 (350), DOI: 10.1186/s12885-023-10835-0
2. Glatzer, M., Panje, C., Sirén, C., Cihoric, N., Putora, P. Decision Making Criteria in Oncology, Oncology, 2020, 98 (6), 370–378, DOI: 10.1159/000492272
3. Josfeld, L., Keinki, C., Pammer, C., Zomorodbakhsch, B., Hübner, J. Cancer patients' perspective on shared decision-making and decision aids in oncology, Journal of Cancer Research and Clinical Oncology, 2021, 147, 1725–1732
4. Pîslaru M. Cercetare Operațională, Performantica, Iași, ISBN 97606-685-232-6, 2015
5. Dupuis, L., Johnston, D., Baggott, C., Hyslop, S., Tomlinson, D., Gibson, P. Validation of the Symptom Screening in Pediatrics Tool in Children receiving Cancer treatments, J. Natl. Cancer Inst., 2018, 110 (6), 661–668.
6. Shoemaker, L., Estfan, B., Induru, R., Walsh, D. Symptom management: An important part of cancer care, Cleveland Clinic Journal of Medicine, 2011, 78 (1), 25-34, DOI: 10.3949/ccjm.78a.10053
7. Cook. S., Vettese, E., Soman, D., Hyslop, S., Kuczynski, S., Spiegler, B. Initial development of supportive care assessment, prioritization and recommendations for kids (SPARK), a symptom screening and management application, BMC Med. Inform. Decis. Mak., 2019, 19 (1), 9.
8. Tomlinson, D., Robinson, P., Gibson, P., Beauchemin, M., Grimes, A., Dadzie, G. Creating and adapting an infection management care pathway in pediatric oncology, Support Care Cancer, 2022, 30 (10), 7923-7934. DOI: 10.1007/s00520-022-07216-x.
9. Dupuis, L., Grimes, A., Vettese, E., Klesges, L., Sung, L. Barriers to symptom management care pathway implementation in pediatric Cancer, BMC Healt.h Serv. Res., 2021, 21(1), 1068