Interection of Real Options Theory and Diagnosis Related Group

Abstract

The hospital environment is considered complex due to the combination of different types of services that need to be performed harmoniously for the final product to be delivered. Given this complexity it is observed the use of Group Related Diagnosis – DRG, a type of patient classification method that assists in hospital management. However, such method is deterministic and does not consider the variations brought by uncertainty regarding the patient's clinical condition. This causes it to add little information to objectively rational decision-making under uncertainty. Therefore, this research aimed to analyze the incorporation of uncertainty and flexibility into the Group Related Diagnosis method through the Real Options Theory - ROT. Thus, we sought to create homogeneous patient groups through an exploratory and documentary research, with a qualitative and quantitative approach, guided by the deductive method. This grouping was based on the combination of diagnoses and outcome of discharge. In addition to the grouping, it was possible to include in the groups the flexibilities that the patient may have during hospitalization, as well as the probabilities of occurrence. Through this research, based on the positivist approach and the functionalist paradigm, it was possible to observe, empirically, the interaction between the ROT and the DRG method. This interaction made possible the proposition of a new classification method, focused on the financial aspects and relevant information provider to make the objectively rational decision.

Keywords: Theory of Real Options; Flexibility; Diagnosis Related Group; Patient Classification System.

1. Introduction

The Theory of Real Options was developed with the objective of changing the way that the phenomena related to investment analysis were evaluated. It brings the concept that a Real Option is the right, but not an obligation, to exercise a certain action (linked to the real asset) over time. This theory adopts the following assumptions:

a) an investment project can be analyzed as an option, and not as an obligation, which each step of the decision-making process is no longer manager by impositions, so the previously defined path can be changed.
b) Real Options have a long life and can be perpetual.
c) the decision to exercise an option in advance or to adopt an investment project is critical.
d) the asset is tangible and is generally not traded, and there is no guarantee that its value cannot be negative.
e) management controls the asset from which the ROT was derived.
f) changes in the value of the asset cause a change in the value of the option.

Based on these assumptions, ROT has the following basic requirements: Irreversibility, Uncertainty and the possibility of Reassessment. Thus, a Real Option can only be created, if these three requirements have been confirmed.

Supported by these concepts, assumptions and requirements, the methods of expanded NPV, binomial / trinomial model and the differential equations for evaluating options are applied. The results found assume the condition that the environment in which investment decisions are made has uncertainties and the Real Options are able to mitigate the negative effects brought about by uncertainty.

In another area of knowledge there is the DRG method. Used to group homogeneous patients in resource consumption, age, sex, combination of diagnoses and procedures performed.

The DRG was created to be the basis of payment in the prospective system, assuming the fact that the longer the hospitalization period, the greater the resource consumption. It determines before the provision of the service the amount to be charged.

In Brazil, when evaluating the time that was actually spent and the estimating time, a significant discrepancy is observed, in which the value consumed is higher than the estimated. It is also observed that some patients hospitalized for a short period of time, had more resource consumption than patients who had long periods of hospitalization.

It is common to find a significant number of patient's records in which the patient remained hospitalized for less than ten days, but underwent several procedures. This led to a high value in relation to resource consumption. The opposite is also observed. There is a record of patients who were hospitalized for long periods of time, but the number of procedures performed was lower, leading to a lower amount of resource consumption. This discrepancy is the reason that many health plans and hospitals do not use DRG for financial purposes.

In the research carried out, no information was found on which theory was used as a "background" to assess the phenomena involved in the application of the DRG method. However, it is observed that uncertainty is not considered by the method during the hospitalization period. This reduces the prospective character of DRG.

In the environment which the hospital product is developed, it is observed: irreversibility of the initial investment in the treatment of the patient; uncertainty related to the lack of future knowledge of the patient's condition, which directly affects the budget for treatment; possibility of reassessment when obtaining more information about future scenarios.

Given the verification of these three requirements, it is possible to model Real Options directly linked to the treatment of the patient. The modeling of Real Options in the treatment was done by Driffield and Smith (2007) and Meyer and Rees (2012). In these papers, the authors used ROT to demonstrate how it can be used in medical decisions related to starting immediately the treatment or waiting.

The applications of Driffield and Smith (2007) and Meyer and Rees (2012) are in agreement with that presented by Fisher (1907). Fisher (1907) allowed us to observe that the options are alternatives or flexibilities, which have a direct correlation with the objective asset.

The research of Dortland et al. (2012), Dortland et al. (2014) and Magiera and McLean (1996) also follow the same concept of options presented by Fisher (1907). In the first, the authors used ROT in a qualitative way and developed a decision support tool. This tool describes the flexibilities and their consequences for health sector organizations. The second research the authors apply the model developed. The third research, Magiera and McLean (1996) used ROT to evaluate the investment in a lithotripsy device. The authors present two options: investment in a fixed lithotripsy device with no option; investment in a mobile device with the option of renting the device to other medical institutes.

Based on the research presented, Real Options are alternatives (flexibilities), which have a direct relationship with the object analyzed. They add value by providing an adaptation to changes in the environment in which the object asset is inserted, being hedging instruments in decision making under uncertainty. Given this concept, it is possible to model Real Options for the treatment of the patient and include them in the DRG method. This inclusion brings the prospective characteristic to DRG, reducing its deterministic bias.

Thus, this paper aims to analyze the incorporation of uncertainty and flexibility in the Diagnosis Related Group method, through the Theory of Real Options, supporting a new paradigm of patient classification.

The justification for this research is linked to the possibility of interaction not previously seen between theory and method.

2. Theoretical Reference

2.1 Real Options Theory

According Copeland and Antikarov (2001) a Real Option represents the right that an entrepreneur has to take an action, where its holder can defer, expand, contract or abandon the project, at a predetermined cost, for a pre-established period. In this way, the Real Option reflects the various investment alternatives (flexibility) of a capital investment project, which in a positive situation a manager can increase the present value of the expected cash flows when exercising the right of action, or in a situation of uncertainty, the manager can minimize losses. Studies on the Theory of Real Options started with Myers (1977). The author described the analogy between the expansion opportunities of a company and the pricing of call options contracts, from the financial market, which had been developed by Black and Sholes (1973).

This transposition changed the current paradigm in relation to the way investment decisions were analyzed. Until then, investment analysis used traditional methods, also known as deterministic. However, they had limitations that led to questions about their effectiveness in investment analysis and in discussions about investing.

For Dixit and Pindyck (1994) the orthodox investment theory does not recognize the implications of the interaction between irreversibility, uncertainty and the choice of the time in which the investment will be made. In this sense, Paddock et al. (1988) add that the deterministic methods can lead the investor to inadequate results for disregarding possible uncertainties that the investment has.

Amram and Kulatilaka (2000) report that traditional methods do not work for business reality, which have:

- ✓ Strategic investments with countless uncertainties and an immense need for capital;
- ✓ Projects that need to adapt to market conditions;
- ✓ Partnerships with complex asset structures and with great pressure from the financial market to adopt strategies that generate value.

In general, deterministic methods neglect that investments are made in scenarios that present uncertainties. This compromises the achievement of objectively rational choices, disregarding the flexibilities present in the environment.

Based on ROT the individual is a rational being, who makes decisions guided by the utility function of the expected utility theory. This premise, together with the functionalist paradigm and the positivist approach, allows the conclusion that it would be wrong to think that other options cannot arise and be able to maximize profit during the execution of the project.

According to Dixit and Pindyck (1994), it is necessary to capture the value of possible alternatives that may arise during the period of implementation of an investment. This is because the investment decision, in most cases, involves the following characteristics:

a) Completely or partially irreversible investment;

b) Existence of uncertainty related to the future return that the investment may provide;

c) Existence of flexibility must be considered by the investor. In this case, the investor must be able to postpone the investment in order to obtain more information about the factors that may affect the return.

Trigeorgis and Mason (1987) inform that these flexibilities add an asymmetry in the probability distribution of the Net Present Value - NPV of an investment. Thus, the project has an Expanded Value - EV that corresponds to the sum of the Additional Option - AO for the possibility of adapting the project and the NPV, according to Equation 1.

$$EV = AO + NPV \tag{1}$$

In this situation, asymmetry expands the expected value of NPV and adds a premium for managerial flexibility.

The paradigm shift brought about by ROT makes it possible to reduce the discrepancy between the estimated values and the values recorded after the investment is made. This change is the same that this research sought to provide to the DRG method. This is done by recognizing the relevance of uncertainty and flexibilities in the objectively rational medical choice process.

2.2 Diagnosis Related Group

According to Mullin (1986), the Diagnosis Related Groups - DRG is understood as a method of classifying patients admitted to acute hospitals. Averil (1985) adds that this classification creates groups of patients considered clinically coherent and similar or even homogeneous in relation to the hospital resources consumed. Thus, the DRG correlates the types of patients seen, with the resources consumed during the entire hospitalization period.

In addition, Fetter and Freeman (1986) add that DRG provides hospital managers and phisician a mechanism to control costs through a more understanding of the hospital's production process, combining management and assistance.

Through statistical and computational techniques with medical knowledge, it is possible to obtain a different way of defining the nosological profile[1] of hospitals. This also allows measuring the hospital product, enabling management based on the control of the medical work process.

DRG is used to manage quality and as a basis of calculation for the prospective payment system (through weights). In Brazil, many of the predictions generated by the DRG do not coincide with the values that are recorded at the end of the service. When analyzing a database grouped by the DRG method, it is possible to observe a discrepancy between the expected number of days of hospitalization and the real time of hospitalization. This leads to discrepancy between estimated and realized costs. Costs are calculated based on weights.

According to DRG Brazil (2017), weights are determined through a combination of demographic variables, severity of the disease and necessary institutional resources, the latter being the expected length of stay, human resources and infrastructure used, diagnostic support resources and the therapy, as well as materials, medicines and other necessary supplies.

In all DRG, the average consumption of resources for all individuals represents the relative weight of the baseline, being 1. Any DRG with a value less than 1 uses fewer resources than the average. DRG with values greater than 1 use more resources than the average.

The DRG assumes the idea that the longer the patient is hospitalized, the greater the resource consumption. However, in the hospital environment it is possible to occur situations where the hospitalized patient, for a period of one day undergoes several procedures It is possible that the procedures performed are not included in the hospital daily rate, which increases resource consumption as well as cost. The opposite is observed. Patients with long periods of hospitalization may undergo few procedures. This results in less resource consumption, therefore less cost. These situations demonstrate that patients with a longer hospital stay will not necessarily have a higher cost.

[1] According to the Ministry of Health of Brazil (2017), it is the set of prevalent diseases and / or incidents in a given community.

In view of the specification of the environment, it is possible to say that the use of a method based on the assumption that the longer the hospital stay, the greater the consumption of resources, can lead to significant distortions between the final value of the provision of services and the estimate.

This use can lead to the problems presented by Ugá (2012).

- Problem 1 - reduction of inputs and intermediate services used in each hospitalization (necessary or not). This changes its production functions, to reduce the cost of hospitalizations.
- Problem 2 - increase in readmissions.
- DRG *Creep*[2].
- Variable quality subordinated to purely financial objectives.

Despite the mentioned points, the DRG continues to be applied empirically for providing the containment of unitary costs of hospitalizations and reducing health expenses. This method provides the construction of hospitals' budgets based on the *case mix*[3], where the total annual amount to be received by the hospital is defined based on the profile of its production.

In Brazil, the use of DRG for aspects related to quality or finances deserves greater attention due to the discrepancy observed in the estimated value of hospitalization time and the hospitalization time counted after hospitalization.

In view of the gaps and issues that deserve improvement, the authors suggest seeking solutions from ROT that can be incorporated into the DRG.

By incorporating the way of analyzing the phenomenon of ugly form by ROT, we have a new method. This method recognizes variations in the patient's scenario as a factor that directly affects resource consumption during hospitalization.

3. Methodology

This is an exploratory and documentary research, with a qualitative and quantitative approach and guided by the deductive method.

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[2] Practices of health professionals who intentionally group patients according to the most resource-intensive DRG in order to increase hospital income.

[3] Hospital production profile, based on patient classification groups with their respective frequencies in hospital production.

The sample consisted of patients admitted to the Social Security Hospital of the State of Minas Gerais - Brazil, from January 2013 to July 2018. These patients had as main diagnosis Acute Myocardial Infarction - AMI. The total number of patients in the sample was 659.

Based on the sample, this study used:

- ✓ DRG 280 Acute Myocardial Infarction, Discharged Alive W Mcc
- ✓ DRG 281 Acute Myocardial Infarction, Discharged Alive W Cc
- ✓ DRG 282 Acute Myocardial Infarction, Discharged Alive W/O Cc/Mcc
- ✓ DRG 283 Acute Myocardial Infarction, Expired W Mcc
- ✓ DRG 284 Acute Myocardial Infarction, Expired W Cc
- ✓ DRG 285 Acute Myocardial Infarction, Expired W/O Cc/Mcc

The data were consulted in a database made available by Hospital Governador Israel Pinheiro. It is noteworthy that semi-structured interviews with a hospital specialist were done to confirm the database data.

The analysis techniques employed were: cluster analysis; descriptive statistics; scenario analysis; probability; decision tree; multinomial model; content analysis.

It is important to highlight that DRG is a grouping method that takes into account the patient's complexity. According to the *Center of Medicare & Medicaid Services* – CMMS (2019), there are groups with *Major Complication or Comorbidity* - MCC (greater intensity), *Complication or Comorbidity* – CC (médium intensity) and *Without Complication or Comorbidity / Major Complication or Comorbidity* – Wo (less intensity).

These groups are obtained by combining the primary and secondary diagnoses. After obtaining the groups by severity, a new refinement is performed based on the criterion of discharge with life or discharge with death.

The grouping criteria mentioned in the previous paragraphs were used in this research to form the groups.

4. Analysis and Discussion of Results

4.1 Grouping

The 659 patients in the sample were grouped according to their level of complexity. *Major Complication or Comorbidity* - MCC (greater intensity), *Complication or Comorbidity*

– CC (médium intensity) and *Without Complication or Comorbidity / Major Complication or Comorbidity* – Wo (less intensity). For this purpose, the PROCV (Excel spreadsheet) was used. After this stage, the patients were grouped according to Table 1.

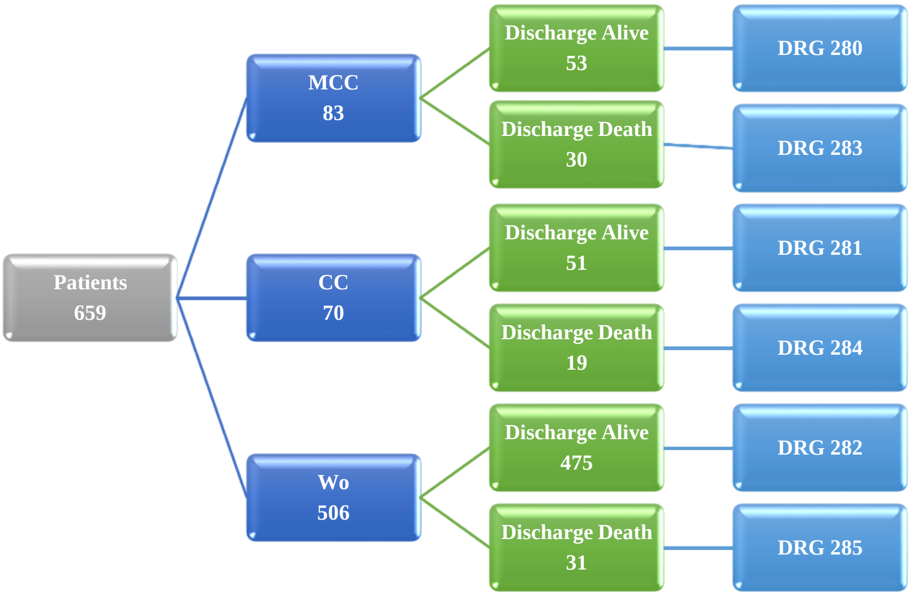
Table 1 - Groups considering severity

First step			
MCC	**CC**	**Wo**	**∑**
83	70	506	659

Source: Result of the research

After grouping, the groups were refined by the criterion of high alive or high death. This allowed the sample to be grouped into the six groups of DRGs that correspond to AMI (Figure 1).

Figure 1 - Final grouping



Source: Elaborated by the authors

It can be said that of the 100% of patients who were hospitalized with a main diagnosis related to AMI, 13% had MCC, 11% WC and 77% Wo.

Of the 11% who had MCC, 64% were discharged alive and 36% were discharged due to death. Of the patients who were classified as severity CC, 73% were discharged alive and 27% discharged due to death. Of the 77% who were considered with Wo, 94% were discharged alive and 6% died during hospitalization.

From this moment it is proposed not to estimate the weights and the hospitalization time, as it is normally done. However, we suggest the incorporation of aspects of ROT, in order to make the DRG method less deterministic and retrospective.

4.2 Real Option Theory and Diagnosis Related Group

In investment analysis, when ROT is applied to make objectively rational choices, we seek as much information as possible in relation to what can happen in each Time (T). This information allows the modeling of flexibilities. Flexibilities mitigate uncertainties and reduce the probability of obtaining a lower than expected return. Based on this and considering that each patient is unique, we sought to verify what happened with each patient treated. Thus, possible scenarios within the same group were identified.

Considering what happened in each T and the sequence of events, 144 different scenarios were mapped. It is noteworthy that there were situations where, in a single T, it was observed the registration of more than one procedure or even the registration of one procedure and constant monitoring (Intensive Care Unit - ICU). Another relevant information is that the T in which the procedure was performed and the hospitalization in the ICU bed can vary from patient to patient. Table 2 shows the number of different scenarios for each DRG.

Table 2 - DRG scenarios

	DRG 280	**DRG 281**	**DRG 282**	**DRG 283**	**DRG 284**	**DRG 285**
Scenarios	24	16	87	20	12	18

Source: Result of the research

It is important to highlight that the eight scenarios presented more frequently encompass 70.68% of the total cases analyzed. The remaining 136 scenarios encompass 31.71% (209 patients). Of these 136 scenarios, 31 had a patient frequency between 9 and 2, and the remaining 105 scenarios had only 1 patient registered.

Each patient is unique, therefore, it can generate a unique situation, and the hospital must be prepared to provide care. These observations reinforce the idea of individuality in the hospital product. This demonstrates the need to consider the flexibilities highlighted by ROT.

Although the DRG seeks to group patients who are similar in several criteria, it is possible to observe the existence of patients undergoing different procedures. In addition, the patient who presents a higher level of criticality during T0 can go through scenarios considered simple. This reinforces the idea of uncertainty about the paths to follow during the hospitalization period.

In this context, the decision on how to proceed is directly correlated with the patient's condition, which may vary in each T. Driffield and Smith (2007) use the same idea. According to the authors, the patient's health status can present three possible situations: 1) without changes; 2) negative evolution; 3) positive evolution.

Depending on the patient's condition and expectations of benefits from treatment, the doctor exercises the option of waiting.

This allows to observe the treatment as a project, where the decision of what will be done in T + 1 is made considering the variation in the patient's clinical condition and the expected benefits of this treatment in T. In cases where the uncertainty about the benefit is intermediate it chooses to exercise the option to wait.

As the Real Option needs to present benefits, in this context, we can listed as benefits: 1) the non-performance of procedures that can bring side effects, as well as pain and anxiety to the patient; 2) Avoiding the consumption of resources, consequently, avoiding the generation of unnecessary costs.

In this research, with the analysis of the patient's clinical protocol and interviews with a specialist, we identified the following decisions: (a) discharge = the patient no longer needs hospital care; (b) intervention = the patient needs care; and (c) monitoring = the patient did not present an intervention record or discharge.

Given these three situations, a scale was inferred in which the patient may present three different types of situations during his hospitalization, namely: (1) positive evolution; (-1) negative evolution; and (0) no variation.

Through this scale, it is possible to observe the patient's clinical condition during the entire hospitalization period, which allows to know when the situation is favorable or unfavorable.

The phisician will define whether the patient has a positive, negative evolution or no change through his technical and tacit knowledge and the condition T_{n-1}. This definition is the starting point for making objectively rational decisions that directly impact the hospital, in care and management issues.

In the hospital, the presence of the uncertainty variable requires a way to analyze the situations that ROT provides. In investment analysis, the evaluation goes through the dilemma of investing or not, and in medical decision making, to intervene or not. Both situations have a common point, objectively rational decision making in an environment where there is irreversibility, uncertainty and the possibility of reassessment.

In both environments, the requirements presented by Dixit and Pindyck (1994) for modeling an option are observed. Thus, it is possible to recognize the existence and influence of options on the future results of investing or intervening.

It is worth mentioning that, despite this point in common, in the case of an investment analysis, decision making is guided by the search for the optimum point that maximizes the return on future cash flows. Thus, it is consistent to consider the uncertainty of the asset's price. In the hospital environment, the return is not just the price of the service. This is because society sees the hospital as a company that deals with health and life, having an obligation to care for them.

4.3 Decision making and flexibility

In view of the complexity in which decisions are made and the possible options, it is necessary to use techniques that seek to minimize the errors of the choices that did not provide the best return. However, before exercising the right to choose, it is necessary to know which alternatives should be evaluated. In the hospital environment, after the identification of the patient's clinical condition, the determination of what will be done occurs, and the possible alternatives are directly linked to the patient's clinical condition and the care protocol.

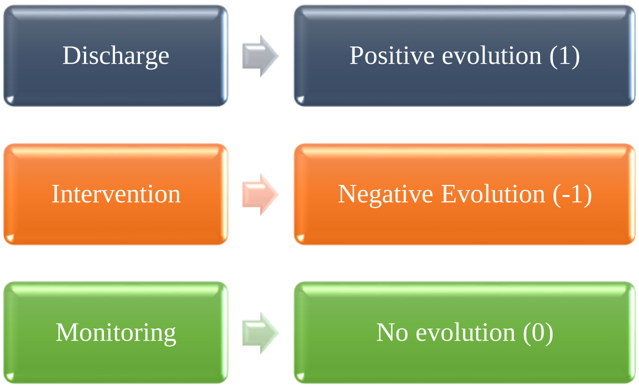
In an interview with a specialist, it was confirmed: when there is no record in the patient's medical record, the patient was monitored, and drugs may have been administered; situations where the record exists means that the informed procedure was performed on the patient. The registered procedures vary according to the patient's needs. However, despite the variation between types, they all consume resources and make up the service package provided that will generate billing in private hospitals or the total reimbursement value in public hospitals.

Regardless of the type of procedure, the word intervention generally represents what happened to the patient on a given day. For this reason, this word was chosen to describe any procedure in which resource consumption occurred and is part of the service package performed on the patient.

Thus, intervention is one of the possible options in objectively rational decision making in this environment. The second option is discharge, granted when there is nothing else the hospital can do for the patient. The third option considers non-intervention and non-discharge.

Based on the scale of clinical evolution presented in the previous section (positive evolution (1); negative evolution (-1); no evolution (0)) and on the observed data, Figure 2 exemplifies how the scale developed relates to the observed situations. It represents the flexibilities in medical decision-making.

Figure 2 - Association between possible decisions and the scale



Source: Elaborated by the authors

Although the research was carried out considering the DRG 280, 281, 282, 283, 284 and 285, for the purpose of exemplifying what was done, in this paper only the data from the DRG 280 will be presented. This was done due to the limitation of pages.

The DRG 280 (AMI, MCC, Discharge Alive) is composed of 53 patients. The hospitalization period varied between 1 - 66, that is T_0, T_1, T_2 ... T_{65}.

When calculating the probability of the observed decisions, the results are shown in Table 3.

Table 3 - Probability of possible day-to-day medical decisions for DRG 280

	Discharge	Monitoring	Intervention	Total
t0	1,89%	90,57%	7,55%	100,00%
t1	0,00%	90,38%	9,62%	100,00%
t2	0,00%	96,15%	3,85%	100,00%
t3	1,92%	94,23%	3,85%	100,00%
t4	1,92%	96,15%	1,92%	100,00%
t5	0,00%	92,16%	7,84%	100,00%
t6	11,76%	82,35%	5,88%	100,00%
t7	0,00%	97,78%	2,22%	100,00%
t8	6,67%	91,11%	2,22%	100,00%

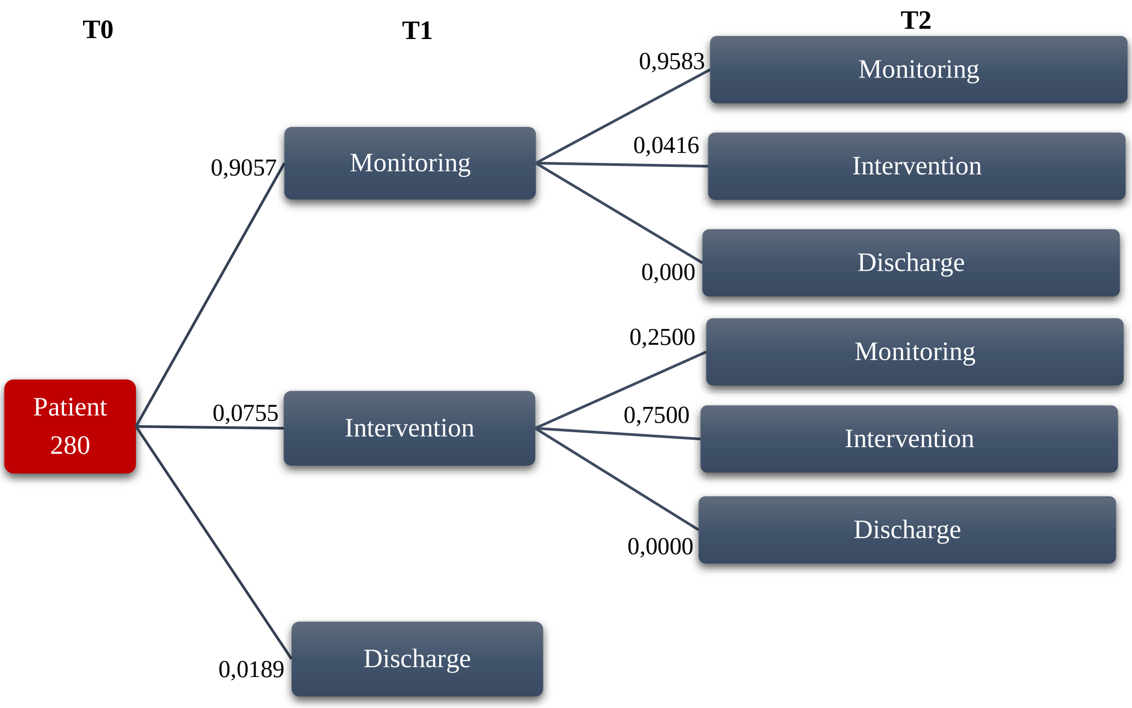
t9	7,14%	92,86%	0,00%	100,00%
t10	2,56%	97,44%	0,00%	100,00%
t11	5,26%	89,47%	5,26%	100,00%
t12	13,89%	77,78%	8,33%	100,00%
t13	3,13%	96,88%	0,00%	100,00%
t14	6,45%	93,55%	0,00%	100,00%
t15	3,45%	93,10%	3,45%	100,00%
t16	14,29%	85,71%	0,00%	100,00%
t17	8,33%	91,67%	0,00%	100,00%
t18	13,64%	77,27%	9,09%	100,00%
t19	10,00%	85,00%	5,00%	100,00%
t20	0,00%	100,00%	0,00%	100,00%
t21	5,56%	94,44%	0,00%	100,00%
t22	11,76%	88,24%	0,00%	100,00%
t23	6,25%	93,75%	0,00%	100,00%
t24	6,67%	93,33%	0,00%	100,00%
t25	7,14%	85,71%	7,14%	100,00%
t26	8,33%	91,67%	0,00%	100,00%
t27	0,00%	100,00%	0,00%	100,00%
t28	0,00%	100,00%	0,00%	100,00%
t29	0,00%	100,00%	0,00%	100,00%
t30	9,09%	81,82%	9,09%	100,00%
t31	0,00%	100,00%	0,00%	100,00%
t32	10,00%	90,00%	0,00%	100,00%
t33	11,11%	88,89%	0,00%	100,00%
t34	0,00%	100,00%	0,00%	100,00%
t35	0,00%	100,00%	0,00%	100,00%
t36	0,00%	100,00%	0,00%	100,00%
t37	12,50%	87,50%	0,00%	100,00%
t38	0,00%	100,00%	0,00%	100,00%
t39	14,29%	85,71%	0,00%	100,00%
t40	16,67%	83,33%	0,00%	100,00%
t41	0,00%	100,00%	0,00%	100,00%
t42	0,00%	100,00%	0,00%	100,00%
t43	0,00%	100,00%	0,00%	100,00%
t44	20,00%	80,00%	0,00%	100,00%
t45	0,00%	100,00%	0,00%	100,00%
t46	25,00%	75,00%	0,00%	100,00%
t47	0,00%	100,00%	0,00%	100,00%
t48	0,00%	100,00%	0,00%	100,00%
t49	0,00%	100,00%	0,00%	100,00%
t50	0,00%	100,00%	0,00%	100,00%
t51	0,00%	100,00%	0,00%	100,00%
t52	0,00%	100,00%	0,00%	100,00%
t53	33,33%	66,67%	0,00%	100,00%
t54	0,00%	100,00%	0,00%	100,00%
t55	0,00%	100,00%	0,00%	100,00%
t56	0,00%	100,00%	0,00%	100,00%
t57	0,00%	100,00%	0,00%	100,00%
t58	0,00%	100,00%	0,00%	100,00%
t59	0,00%	100,00%	0,00%	100,00%
t60	50,00%	50,00%	0,00%	100,00%
t61	0,00%	100,00%	0,00%	100,00%
t62	0,00%	100,00%	0,00%	100,00%
t63	0,00%	100,00%	0,00%	100,00%
t64	0,00%	100,00%	0,00%	100,00%
T65	100,00%	0,00%	0,00%	100,00%

Source: Result of the research

Similar to the idea of investing now or waiting, the doctor should assess whether he monitors (waits) or intervenes (invests). However, in the hospital environment, one more option is added; it is discharge.

Considering these three alternatives, it is possible to create a tree that presents the probabilities in each T of the chosen alternatives. Given the size of these trees, Figure 3 shows a cutout, referring to T_0, T_1 *e* T_2 in DRG 280.

Figure 3 – Exemple of trinomial tree related to DRG 280 decision making



Source: Result of the research

Figure 3 allows to extract from the historical data of the DRG the probability of incidence of each option exercised by the physician. From a managerial point of view, this information adds elements to the DRG that can be used as a basis for making estimates in relation to operational, financial and human resources planning.

The incorporation of options to the DRG method provides recognition of the uncertainty and flexibility in the treatment of the patient, variables that are already considered empirically in the hospital's daily routine. This provides an adapted application of the guidance given by

Dixit and Pindyck (1994). According to the authors, it is necessary to capture the value of possible alternatives that may arise during the period of implementation of an investment.

In this research, we sought to capture the value of possible alternatives that may arise over the period of hospitalization, where the decision to monitor costs the hospital the value of a daily rate. Discharge discontinues resource consumption and the intervention consumes resources that can vary from patient to patient.

The action of intervening can refer to any procedure performed on the patient. However, in relation to the financial aspect, it is known that each type of intervention can have a different value. In the same way when you choose to invest. The way in which this investment will be made can also lead to a change in value. However, in an investment analysis the variables are fixed. In the context in which the research was developed, there is no such possibility because as the deterministic aspect we traiyng to reduced as much as possible.

4.4 The option of options

When exercising the option to intervene, it is necessary to decide how the intervention will be carried out. Again, the phisician's technical and tacit knowledge will be fundamental in deciding what to do during this intervention.

In the investment analysis, the variables, in all Ts, were determined at the moment before the evaluation. However, due to the characteristic of the object analyzed in this study, this is not possible. Thus, it is impossible to add to the DRG exact information about how the patient will go until his discharge.

What we can do is retrieve the information contained in the observed scenarios, allowing us to obtain the types of interventions that have been carried out in patients with AMI.

It is important to highlight that the interventions are directly related to the main and secondary diagnoses. In other words, the intervention options are directly linked to the patient's clinical condition and should not be chosen based on financial aspects.

As the procedures are linked to the diagnosis, it is possible to have a better characterization, this will limit the possible interventions, as well as their values.

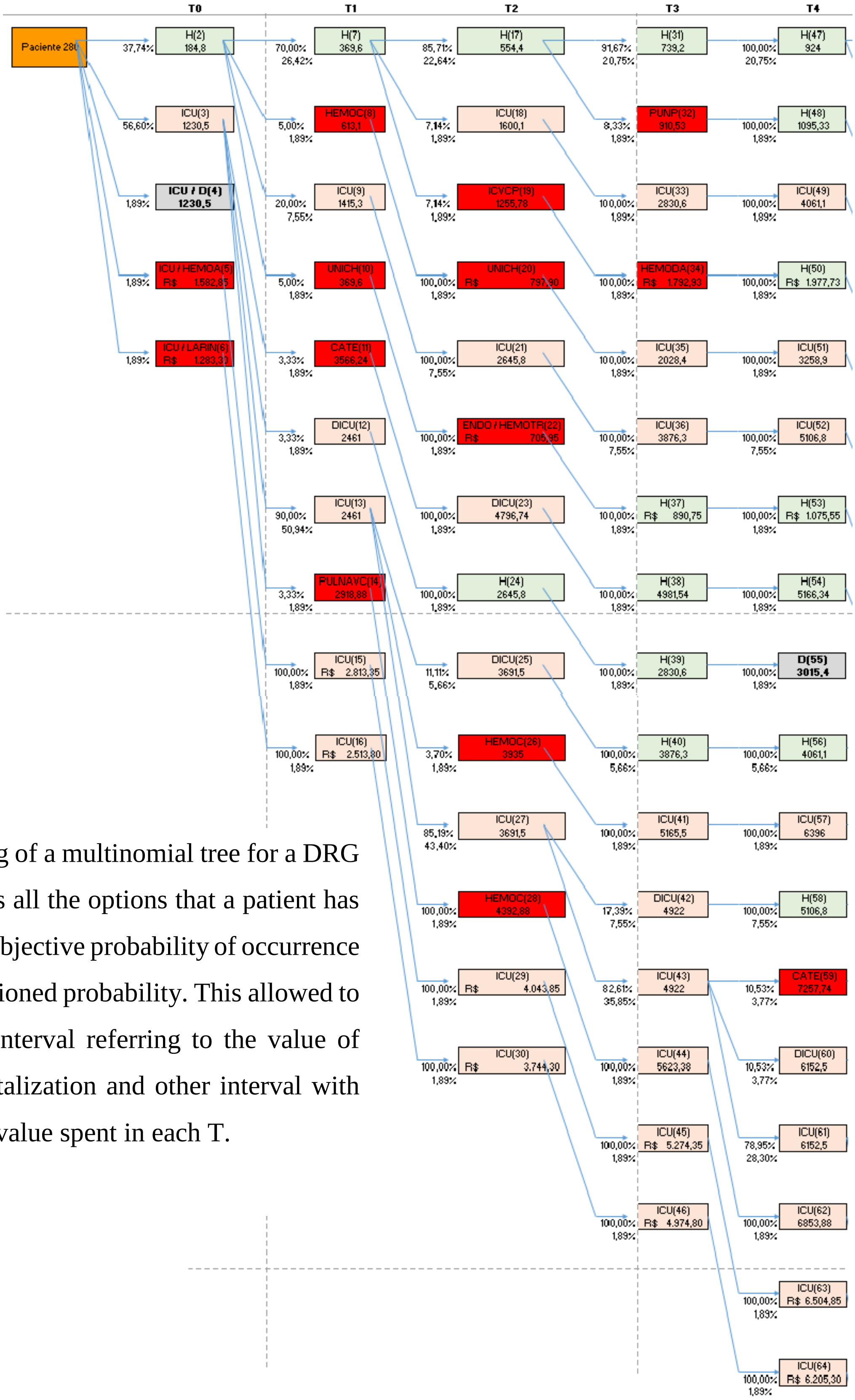
This brings a greater degree of precision to objectively rational decision-making and guides the next steps in intervening. It should be noted that this option involves consuming more resources, which can cause pain and anxiety to the patient.

The decision on how to intervene in the medical field is sometimes something that changes, even though it was defined at the time of analyzing the information about the patient's clinical condition. This change is due to the way the patient reacts. An example of this is the initial choice to perform a catheterization and during the procedure it is necessary to implant a stent.

In a previous analysis, stent implantation was not an option at the time of the decision to perform a catheterization. However, during the intervention (catheterization) it was necessary to implant a stent because failure to implant could compromise the desired return. Situations like this can happen and the hospital needs to be prepared to meet this demand. This reinforces the need to have a method that is not deterministic. Based on this idea, a multinomial tree was created (Figure 4), which not only contemplates the options for monitoring, intervention and discharge, but also details the type of monitoring and intervention.

The illustrated multinomial tree referring to DRG 280 (AMI, MCC, Discharge Alive) in which: hospitalization (H) and intensive care unit (ICU) represent the monitoring options. Discharge (D) refers to the discharge option. Finally, there are the options for interventions that vary in each T. For example, at T_0 there was a record of hemodialysis in acute cases (HEMOA) and laryngoscopy / tracheoscopy (LARIN). In T_1, the intervention options include chronic hemodialysis (HEMOC), red blood cell concentrate (UNICH), catheterization (CATE), new central venous access pulse (PLUVAC).

Figure 4 - Part of the DRG 280 multinomial tree



The formatting of a multinomial tree for a DRG group presents all the options that a patient has in each T, its objective probability of occurrence and the conditioned probability. This allowed to elaborate an interval referring to the value of days of hospitalization and other interval with the monetary value spent in each T.

Source: Result of the research

The tree in Figure 4 shows the reimbursement values practiced by the hospital that made the data available for this study. Their intervals are shown in Table 4.

Table 4 - Example of the range of reimbursement amounts in each DRG 280

	Minimum value	Maximum value	Average value	Standard deviation
t0	R$ 184,80	R$ 1.582,85	R$ 1.102,39	R$ 477,15
t1	R$ 369,60	R$ 3.566,24	R$ 1.950,19	R$ 1.104,76
t2	R$ 554,40	R$ 4.796,74	R$ 2.750,11	R$ 1.442,07
t3	R$ 739,20	R$ 5.623,38	R$ 3.477,45	R$ 1.699,85
t4	R$ 924,00	R$ 7.257,74	R$ 4.465,10	R$ 2.066,75

Source: Result of the research

For the DRG method, the information presented in the multinomial tree provides a great gain. Through its results, the manager will have a clear view of the cost values, or the reimbursement values, or the invoice values at each time the patient is hospitalized, plus the probability of occurrence, as seen in Figure 4.

This way of organizing and crossing assistance and financial information allows the DRG to overcome the problems observed and reported on its static and deterministic nature. The information previously provided by the DRG on the financial aspects was based on weights with average consumption values. However, by bringing the minimum and maximum values, it is possible to get even closer to what was accomplished.

The recognition of irreversibility, uncertainty and the possibility of reassessment, provided by ROT offers the hospital manager a method that incorporates the options that can be exercised or not, it depends on the clinical condition of the patient. Thus, it is possible to have ranges of values for the time of hospitalization and the reimbursement amount.

The incorporation of intervals with probability is better suited to the needs of hospital management. This change does not mean requiring less control of spending by managers, but it does allow them to work within an interval considered consistent with reality.

4.5 Value of flexibility and return

According to Kulatilaka and Marks (1988), one of the most significant advantages of flexibility is to provide the production process the ability to change in the face of uncertainty. In the hospital environment, this advantage is essential in order to be able to offer a quality service, to avoid the death of the patient and / or to provid a better quality of life. As shown in Figure 2 and Figure 3, the option to “intervene” has several intervention options, which reinforces the application of ROT.

In the hospital environment, optionality is common and necessary for the main purpose of providing services to be achieved. Thus, including these options in a classification method is necessary.

Studies such as those by McDonald and Siegel (1985, 1986) and Mason and Merton (1985) highlight the economic value of flexibility, in terms of option value. These studies allow us to infer that when an option has value, it adds value to the project's return and increases cash flows, consequently, the NPV.

The way to calculate the value of an option can vary between partial differential equations, dynamic programming and simulation. In this research, given the characteristic and the need, the dynamic programming model was chosen. Thus, the option value in each T was calculated using the values in each node of the tree together with the probability of occurrence.

Table 5 shows the values found for the DRG 280 (AMI, MCC, Discharge Alive).

Table 5 - Value of options - DRG 280

	Valor da opção	
t0	R$	843,54
t1	R$	1.746,01
t2	R$	2.662,89
t3	R$	3.505,18
t4	R$	4.085,39
t5	R$	4.840,94
t6	R$	21.721,77
t7	R$	6.309,63
t8	R$	6.148,37
t9	R$	6.575,46
t10	R$	6.525,39
t11	R$	6.394,09
t12	R$	6.641,03
t13	R$	6.192,71
t14	R$	6.320,12
t15	R$	6.533,70
t16	R$	6.144,18
t17	R$	6.223,21
t18	R$	5.273,37
t19	R$	5.030,39
t20	R$	4.728,20
t21	R$	4.830,52
t22	R$	4.932,85
t23	R$	4.818,79
t24	R$	4.551,16
t25	R$	4.649,56
t26	R$	4.908,29
t27	R$	4.036,60
t28	R$	3.865,44
t29	R$	3.930,17
t30	R$	3.994,90
t31	R$	4.068,27
t32	R$	3.499,45
t33	R$	3.635,63
t34	R$	3.561,65
t35	R$	3.094,96
t36	R$	3.136,04
t37	R$	3.177,12
t38	R$	3.218,20
t39	R$	2.809,18
t40	R$	2.846,77
t41	R$	2.714,21
t42	R$	2.225,39
t43	R$	2.256,01
t44	R$	2.286,63
t45	R$	2.317,25
t46	R$	1.874,35
t47	R$	1.914,67
t48	R$	1.579,99
t49	R$	1.603,64
t50	R$	1.627,29
t51	R$	1.650,93
t52	R$	1.661,40
t53	R$	1.671,86
t54	R$	1.352,33
t55	R$	1.359,30
t56	R$	1.366,28
t57	R$	1.373,25
t58	R$	1.380,23
t59	R$	1.387,20
t60	R$	1.394,17
t61	R$	934,61
t62	R$	938,10
t63	R$	941,58
t64	R$	945,07

Source: Result of the research

According to ROT, when using the binomial model for pricing Real Options, the Risk-Neutral Probability is used and not the objective probability.

Despite this rule presented by ROT, in this research objective probability was used in the calculation of weighted averages, this is because in this article the time interval is one day, different from the time interval when evaluating investments (generally, one year).

When considering that the flexibilities incorporated in the DRG allow phisician to choose actions that prolong the patient's life, the return goes beyond the reimbursement, the invoice amount or the provision of services required by Brazilian law. So it can be said that the return is given by Equation 2:

$$GR = (SRV - SE) + LV \tag{2}$$

Where GR represents the general return, SRV is the service reimbursement value, SE refers to the service expenses and LV is the life value.

Thus, when considering that

1. Reimbursement amount for a patient belonging to DRG 280, who was discharged in t4, was R$ 3,015.40;

2. Hypothetically, expenditure amount was 70% of the reimbursement value;

3. Hypothetically, life value is R$ 436,230.67.

The return, in this specific case, is:

$$GR = (3.015{,}40 - 2.110{,}78) + 436.230{,}76$$

$$GR = R\$\ 437.135{,}38$$

When expanding this logic to all time of the DRG 280 (IAM, MCC, Discharge Alive), we have Table 6.

Table 6 - Reimbursement amount and expenses for DRG 280

	Total reimbursement	Total Expenses	Reimbursement - Expenses
t0	R$ 1.230,50	R$ 861,35	R$ 369,15
t4	R$ 3.015,40	R$ 2.110,78	R$ 904,62
t7	R$ 31.593,84	R$ 22.115,69	R$ 9.478,15
t9	R$ 20.893,30	R$ 14.625,31	R$ 6.267,99
t10	R$ 23.246,79	R$ 16.272,75	R$ 6.974,04
t11	R$ 7.446,10	R$ 5.212,27	R$ 2.233,83
t12	R$ 18.062,70	R$ 12.643,89	R$ 5.418,81
t13	R$ 39.519,83	R$ 27.663,88	R$ 11.855,95

t15	R$ 23.034,64	R$ 16.124,25	R$ 6.910,39
t16	R$ 10.466,80	R$ 7.326,76	R$ 3.140,04
t17	R$ 43.940,09	R$ 30.758,06	R$ 13.182,03
t18	R$ 26.272,54	R$ 18.390,78	R$ 7.881,76
t19	R$ 22.596,00	R$ 15.817,20	R$ 6.778,80
t20	R$ 13.302,70	R$ 9.311,89	R$ 3.990,81
t22	R$ 10.584,14	R$ 7.408,90	R$ 3.175,24
t23	R$ 18.354,57	R$ 12.848,20	R$ 5.506,37
t25	R$ 4.804,80	R$ 3.363,36	R$ 1.441,44
t26	R$ 49.814,57	R$ 34.870,20	R$ 14.944,37
t27	R$ 12.502,08	R$ 8.751,46	R$ 3.750,62
t31	R$ 28.722,38	R$ 20.105,67	R$ 8.616,71
t33	R$ 6.283,20	R$ 4.398,24	R$ 1.884,96
t34	R$ 26.911,82	R$ 18.838,27	R$ 8.073,55
t38	R$ 23.670,90	R$ 16.569,63	R$ 7.101,27
t40	R$ 8.833,59	R$ 6.183,51	R$ 2.650,08
t41	R$ 27.530,40	R$ 19.271,28	R$ 8.259,12
t45	R$ 25.610,60	R$ 17.927,42	R$ 7.683,18
t47	R$ 18.991,20	R$ 13.293,84	R$ 5.697,36
t53	R$ 17.304,40	R$ 12.113,08	R$ 5.191,32
t60	R$ 24.541,55	R$ 17.179,09	R$ 7.362,46
t65	R$ 50.273,60	R$ 35.191,52	R$ 15.082,08
Total	R$ 639.355,03	R$ 447.548,52	R$ 191.806,51

Source: Result of the research

Knowing that the frequency of DRG 280 was 53 patients, it can be said that:

$$GR = (639.355{,}03 - 447.548{,}52) + 23.120.225{,}51$$

$$GR = R\$\ 23.312.032{,}02$$

Therefore, the return obtained for the provision of the service related to DRG 280 was R$ 23.312.032,02.

This simulation performed with the DRG 280 (IAM, MCC, Discharge Alive) aimed to demonstrate that the incorporation of the techniques presented, also allows adding to the DRG method the discussion on the return value, whether considering the value of life or not.

5. Final Considerations

The use of ROT as a way to interpret the phenomena in which the DRG method is applied provides the recognition that each stage of treatment is an option, not an obligation. Each step of the decision-making process is no longer governed by impositions, in which it is possible to change the previously defined route, as long as it is within the clinical protocol.

Supported by a positivist approach and the functionalist paradigm, this research based on evidence allowed to fulfill the main objective: to analyze the incorporation of uncertainty and flexibility in the DRG method, based on ROT.

The idea of Real Options employed in this paper follows a different bias from what is commonly observed in investment analysis, in which the incorporation of Options for Waiting, Abandonment, Exchange, Learning, Expansion, etc..

In this paper, the idea that flexibility represents the alternative of investing in a capital investment project was recovered. In this context, the manager, in a positive situation, can increase the present value of the expected cash flows when exercising the right of action. On the other hand, in an uncertain situation, to minimize losses. Real Pption is a flexibility or an alternative. Based on this concept, it was possible to explore the Real Options in medical decision-making, extrapolating its concept to other types of alternatives that are directly linked to treatment.

Therefore, focus on the idea that alternatives should be treated as a form of hedge, when exercised they can avoid the death of the patient. This made to develop a new method of DRG, called DRG-M that considers a Real Option as a right, and not an obligation in treatment. In this context, the phisician, within the clinical protocol, can and must change the treatment path designed at the T_0.

The DRG-M considers the irreversibility of the initial investment in treatment, the uncertainty related to the patient's clinical evolution and the possibility of postponing an action to obtain more information about the patient's condition as requirements. The DRG-M's assumptions are:

I. The stages of treatment can be analyzed as options and not as an obligation, in which the decision-making process is no longer governed by impositions and the previously defined course can be changed;
II. Real Options are short-lived;
III. The decision to exercise an option in advance or to adopt treatment is critical;
IV. The object asset is intangible, commercialized, with no guarantee that its return cannot be negative;
V. The management and the physician control the underlying asset from which the Real Option was derived;

VI. Changes in the value of the underlying asset cause a change in the value of the option.

Thus, through this research it was possible to reaffirm the relevance of flexibilities in the environment of uncertainty and demonstrate how they mitigate the risk involved in financial planning and decision making, whether related to management or medical.

The limitations of the research are: the non-presentation of decision trees with cost values. This would make it possible to conduct an analysis between reimbursement value and cost. However, the lack of this information meant that trees were created with only the reimbursement amount. As future research, it is suggested to expand the studied sample.

6. Reference

Amram, M., & Kulatilaka, N. (2000) Strategy and shareholder value creation: the real options frontier, Bank of America. *Journal of Applied Corporate Finance*, New York. v. 13. n. 2, p. 8-21.

Averill, R.F. (1985). The design and development of the Diagnosis Related Groups. *In: Health Systems International. Diagnosis Related Groups;* second revision definitions manual. New Haven, Conn.

Black, F., & Scholes, M. (1973) The pricing of options and corporate liabilities. *Journal of Political Economy*. p.637-659. May/June.

Centers for Medicare and Medicaid Services. (2019). Major Diagnostic Category. Recuperado de: www.cms.gov.

Copeland, T., & Antikarov, V. (2001) *Opções Reais.* Editora Campus, Rio de janeiro, 2001.

Dixit, A. K.; Pindyck, R. S. (I994). *Investment under uncertainy.* Princeton: Princeton University.

Driffield, T., & Smith, P. C. (2007) A real options approach to watchful waiting: theory and an illustration. *Medical Decision Making* 27 (2):178-188.

Dortland, M. V. R., Voordijk, H., & Dewulf, G. (2012). Towards a decision support tool for real estate management in the health sector using real options and scenario planning. *Journal of corporate real estate*, *14*(3), 140-156.

Dortland, M. V. R., Voordijk, H., & Dewulf, G. (2014). Making sense of future uncertainties using real options and scenario planning. *Futures*, *55*, 15-31.

Fetter, R. B., & Freeman, J. L. (1986). Diagnosis related groups: product line management within hospitals. *Academy of management Review*, *11*(1), 41-54.

Fisher, I. (1907). *The rate of interest* (p. 442). New York: Macmillan.

Magiera, F.T., & Mclean, R. A. (1996) Strategic options in capital budgeting and program selection under fee-for-service and managed care. Health Care Manage Rev 21 (4):7-17.

Myers, S. (1977). Determinants of capital borrowing. *Journal of Financial Economy*. Rochester, v. 5, p. 147-175.

Meyer, E., & Rees, R. (2012). Watchfully waiting: Medical intervention as an optimal investment decision. *Journal of health economics*, *31*(2), 349-358.

Mullin, R.L. (1986). Development of DRGs. In: International Conference on Management and Financing of Hospital Services, London, 1986. *Proceedings*. London, Health Systems International.

Ugá, M. A. D. (2012). Sistemas de alocação de recursos a prestadores de serviços de saúde-a experiência internacional. *Ciência & Saúde Coletiva*, *17*, 3437-3445.

Paddock, J. L., Siegel, D. R., & Smith, J. L. (1988). Option valuation of claims on real assets: the case of offshore petroleum leases. *Quarterly Journal of Economics*, v. 103, n. 3, 479- 508.

Trigeorgis, L., & Mason, S. (1987). Valuing managerial flexibility. Midland Corporate Finance Journal, N 5 V1, 14-21.