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DETERMINATION OF CARE PRICE IN HEALTH PLANS USING SIMULATION

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ABSTRACT

In an extremely competitive market such as supplementary health, it is of fundamental importance to build advantages over competing companies. In economies of scale, one way to become competitive is to keep prices in a cluster smaller than the competition. The present study aims to show a simplified procedure for the determination of per capita care costs and also show the importance of the size of the insured group for the technical solvency charge, a direct consequence of the Large Numbers Act, first described by Jakob Bernoulli. For this purpose, historical data were used, using the Monte Carlo simulation technique. The research is classified methodologically as bibliographical, documentary and laboratory in computer environment. The data are real and were obtained from a health care provider in the city of Fortaleza. In practical terms, this study collaborated with decision-makers working in the area of supplementary health, regarding the determination of the cost of care, a component of the price to be charged by a health plan.

Keywords: Health insurance; Simulation of Monte Carlo; Actuarial Calculation.

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1. INTRODUCTION

The decay of the public health system in Brazil is visible. Due to problems of political and economic orders, the structure of health care has become very precarious. Public hospitals are provided with equipment with outdated technology and the state technical staff of nurses, physicians, physiotherapists and other health professionals is insufficient to meet the needs of the population.

Faced with this situation, health care providers sought to gain an increasingly large market share. In the search for new customers, it is of fundamental importance to build competitive advantages. One of the items that can compose a competitive advantage is the price of the health plans offered by the insurance company.

Although the complementary health sector is essentially private, the Government, acting as protector of citizens' interests, created the *Agência Nacional de Saúde Suplementar* (ANS - National Supplementary Health Agency), through Law 9,961 of January 28, 2000. The article 3 of this law states that ANS has the institutional purpose of promoting public interest in supplementary health care, regulating sector operators, including their relationships with service providers and consumers, thus contributing to the development of health actions in the country.

At the time of defining which price should be adopted, in a specific plan, companies should analyze several variables. The number of customers in the plan portfolio in question, the price charged by other operators in similar plans, the costs related to each user of the plan and the probability of the revenues obtained to cover the costs. These are some of the most important variables and will be considered in the study to be performed.

The present study aims to show a simplified procedure for the determination of per capita care costs and the importance of the size of the insured group for the technical load of solvency. Thus, it is understood that the present study contributes to the academic world, showing a simplified procedure for the determination of the per capita assistance costs, using the Monte Carlo Simulation, and also showing the importance of the size of the insured group for the technical solvency charge.

In this study, the client portfolio of a health plan with approximately 114,000 users, a stable population in the last 12 months, was used, and the inflation rate, used to readjust healthcare costs, was obtained through a weighted average of the main inflation indices.

2. THEORETICAL REFERENCE

2.1 Simulation

The word simulation refers to any analytical method whose intention is to imitate some real system, especially when other analyzes are mathematically complex. By system is understood the set of components that act and interact in order to reach a certain objective. The study of a system can be done through observations in the real system or from the elaboration of a model that allows its understanding and the prediction of its behavior under certain conditions (Lustosa et al., 2004). We can understand the classification of the systems study by Figure 1.

The simulation, therefore, is a technique that allows reproducing the operation of a system, with the help of a model, and generating expectations of results. The models, in turn, can be physical or mathematical. Mathematical models represent, in logical and quantitative terms, the relationships between variables. When it is possible to determine the values of the variables, the model has an analytical solution. When these values are not known, the solution should be searched through simulation (Lustosa et al., 2004).

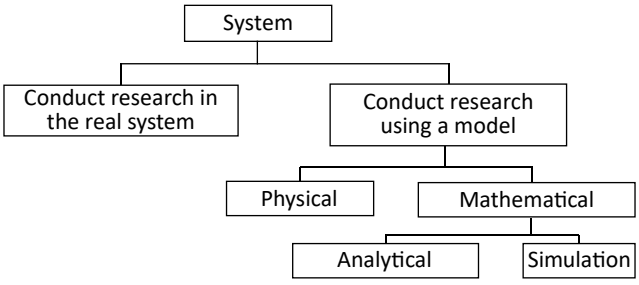

Figure 1. Ways to study a system
Source: Law et Kelton (1991)

Thus, the purpose of the simulation is to describe the distribution and characteristics of the possible values of a dependent variable, after determining the possible values and behaviors of the related independent variables (Winston, 2004). Thus, the simulation can be approached by practically any theme such as, for example, paper recycling contained in municipal solid waste (Simoneto et al., 2014), stock replenishment system (Beck et al., 2015), annual average cost of a bus fleet (Riechi et al., 2017) and financial viability for the generation of clean energy (Catapan *et al.*, 2016).

In many cases, simulation models are used to analyze a decision involving risk, that is, a model in which the behavior of one or more factors is not known with certainty. In this case, these factors are known as random variables, and their behavior is described by a probability distribution (Moore

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et Weatherford, 2005). The Monte Carlo Method is therefore a simulation model that uses the generation of random numbers to assign values to the variables to be investigated. Random numbers can be obtained directly from the computer through specific functions (Lustosa et al., 2004).

The work of Silva et al. (2015) presented a simulation model for discrete events in an attempt to describe, approximately, the functioning of the adult emergency of a hospital. As a result, the authors verified that a large part of the users of the health system sought the medical unit because it sought a faster service, even though it did not require an emergency treatment.

The model developed in the research by Paulo et al. (2017) presents itself as an adequate tool for optimal allocation of financial resources. Therefore, according to the authors, their use provides better conditions for the decision-making process of risk management.

Di Giorgio et al. (2016) developed a model in a simulation environment that reproduced the characteristics of the production of health services to increase the validity and reliability of the efficiency analyzes. The results of this study served as a basis for the promotion of policies on improving the efficiency of the production of health services.

2.2 Health

In Brazil, health care is carried out in three ways: private, the public system (*Sistema Único de Saúde* - SUS) and the system of supplementary health care. According to Ugá et Santos (2006), the participation of the public sector in the Brazilian health expenditure is 43.8%, the supplementary assistance system is 21.7%, and finally, the exclusively private care, which is responsible for 34.5%.

The supplementary health system began in the 1960s with group medicine, basically aimed at the care of the working class that settled in the metropolitan region of São Paulo. This system of prepayment for the provision of medical services arose with the organization of some doctors who were dedicated to attending this demand, dissatisfied with the precariousness of public services in the region and the high cost of liberal medicine.

In the 1980s, with the flourishing of the health axiom as direct to life, private medical-hospital assistance programs significantly increased their participation in the health care model, primarily through group medicine companies and medical cooperatives. According to Bahia (2001b), this expansion of supplementary medical care occurred due to the insufficient capacity of SUS. In this same period, the 1988 Constitution came to guarantee, theoretically, health care as a citizen's right and a duty of the State.

However, many of the health plan users continued to use SUS in cases where an item was not offered, especially in high-cost and high-complexity treatments, or to perform typical public health activities such as vaccination (Bahia, 2001a).

In 1998, the Government created the ANS, through Law 9,656/1998, due to constant complaints in the Consumer Protection Program (PROCON) against health plan operators. In this agency were established the registration and authorization of operation, obligation to provide financial information, user registration and the establishment of compensation to the SUS due to the public-sector burden on procedures that should be done by the supplementary health sector.

Another important change that entered into force with Law 9,656/1998 was the establishment of seven age groups, avoiding, on the part of the operators, the discrimination of consumers of very advanced age. In this way, the operators became interested in all audiences, regardless of age, according to the need to satisfy them to keep them in their portfolio and, consequently, to generate a more positive image of the plan aiming at the conquest of new clients.

Vavra et Pruden (1995) argue that customer retention is the key to success in the new millennium market and is proposed as the most important component for consolidating the company's market share and is basically driven by customer satisfaction. Thus, defensive marketing strategies, based on customer retention, are highlighted in the literature and are suggested by several researchers.

According to Reichheld (1993), it cannot be denied that profits are important not as an end in themselves, but because they allow the company to improve the generation of value and provide incentives for customers to remain retained and loyal to the company. Still, for the author, as a step resulting from customer retention, it is imperative to remember that the benefits of loyalty are often the reasons why one competitor is more profitable than another.

In order to serve all social classes, health plans provide its users with medical-hospital, dental and laboratory services at all levels and budgets. With the aim of adding more consumers to their portfolio, operators can reduce the costs of their services and offer a more affordable monthly payment, but with Law No. 9,656, some measures were taken to balance the market, prohibiting health insurance companies to operate at a price below market cost.

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3. METHODOLOGY

The general objective of this paper is to show a simplified procedure for the determination of the per capita assistance costs and the importance of the size of the insured group for the technical load of solvency. Using data from a specific health plan, a procedure will be presented to determine the price of care, considering the degree of solvency of health-care costs, through computer simulation, and will present factors that may change this degree of solvency.

For that, statistical and experimental methods were used. According to Fachin (2001, page 41), "it is called an experimental method in which the variables are manipulated in a pre-established manner and their effects are sufficiently controlled and known by the researcher to observe the study".

The statistical method applies to the study of random phenomena, and virtually all phenomena occurring in nature are random. This method is based on the set of procedures supported by the sampling theory and, as such, is indispensable to the study of certain aspects of the social reality in which one intends to measure the degree of correlation between two or more phenomena (Fachin, 2003).

As far as the initial part of this work is concerned, the type of research used will be the exploratory one, since the intention is to contextualize the reader in the problem to be approached. In its final part, it will present characteristics of applied research, as it will demonstrate existing relationships in the exploratory research. The first of the parties uses bibliographic and documentary research. The bibliographical research tries to explain a problem from theoretical references published in documents. The bibliographical research consists of the examination of this spring for the survey of what has already occurred on a certain subject (Fachin, 2001).

According to Fachin (2001, page 152), "documentary research consists of the collection, classification, diffuse selection and the use of all sorts of information, also including the techniques and methods that facilitate its search and identification".

4. PROCEDURE

Data from the health care costs of a given health plan were obtained from a health care provider in Fortaleza-CE. These data were classified into six categories, namely, examinations, consultations, therapies, other procedures, hospitalizations and other medical expenses. For each of these categories, a frequency distribution of care costs was calculated, shown briefly in Figure 2.

As an example, the value of the probability of the cell C3 (0.68312) was obtained by dividing the frequency of 77,438 of the care cost by R$ 0.00 and the total number of clients (113,359). The same procedure was used to calculate the other probabilities.

In another worksheet, using the functions =Random() and = VLOOKUP(), the hypothetical cost of each of the 113,359 clients that compose the portfolio of the study plan for each of the categories was calculated. The function =Random() generates a random number that will be searched for by the function = VLOOKUP() in the frequency distribution of the indicated class and will return the attendant cost related to that value.

As an example, in Figure 3, in the first row, second column, we have the function =VLOOKUP(RANDOM(); Exams! $C$3:$E$163;3). The function will search in which line the value generated by the function =Random() fits, considering the intervals created by the values of columns C and D, re-

	A	B	C	D	E	F
1	R$	Freq.	Probability	Interval		R$
2				Start	End	
3	0,00	77.438	0,68312	0	0,68312	0,00
4	16,12	3	0,00003	0,68312	0,68315	16,12
5	25,00	1.098	0,00969	0,68315	0,69283	25,00
6	25,20	122	0,00108	0,69283	0,69391	25,20
...	...	...	...	...	...	...
159	285,60	1	0,00001	0,99995	0,99996	285,60
160	289,20	1	0,00001	0,99996	0,99997	289,20
161	295,80	1	0,00001	0,99997	0,99997	295,80
162	329,40	1	0,00001	0,99997	0,99998	329,40
162	329,40	1	0,00002	0,99998	1	336,00
TOTAL		113.359				

Figure 2. Care costs of the category Exams
Source: Own research

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	A	B	...	H
1	User	Exams	...	Total cost of each client
2	1	=VLOOKUP(RANDOM();Exams!$D$3:$F$163;3)	...	=SUM(B2:G2)
3	2	=VLOOKUP(RANDOM();Exams!$D$3:$F$163;3)	...	=SUM(B3:G3)
	...	...	...	...
113358	113.357	=VLOOKUP(RANDOM();Exams!$D$3:$F$163;3)	...	=SUM(B113358:G6B113358)
113359	113.358	=VLOOKUP(RANDOM();Exams!$D$3:$F$163;3)	...	=SUM(B113359:G6B113359)
113360	113.359	=VLOOKUP(RANDOM();Exams!$D$3:$F$163;3)	...	=SUM(B113360:G6B113360)

Figure 3. Costs of care per user
Source: Own research

turning, as a result, the constant value in the third column of the interval from C3 to E163. It is exemplified by considering that the function = Random() generated the number 0.68. Because it is included in the first interval, the function returns the value 0 (zero) for the attendance expense related to the query class for this user.

Adding the hypothetical care costs, in the six cost classes, for all users, we have the total cost of care. Dividing the total care cost by the number of users, we have the average care cost of the plan. The repetition of this process will generate data for the construction of the cumulative frequency histogram of the dependent variable average cost of care, allowing a better understanding of this phenomenon.

5. RESULTS

In the simulation, 30,000 variances of the average care cost were generated. Figure 4 shows the 30,000 predictions, exactly in the order they were generated.

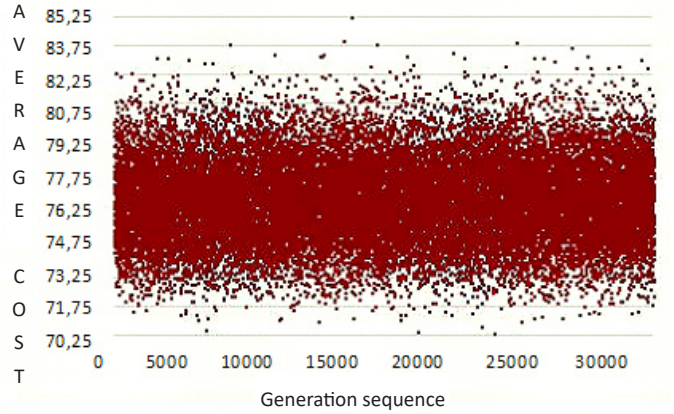

Figure 4. Scatter plot of simulated values
Source: Own research

After generating the 30,000 possible average care costs, these values were ordered, and are shown in Figure 5. Thus, it is easy to see these values, ranging from R$ 68.77 to R$ 85.15.

The ordered values allow a better perception of the risk of the activity, because each of these values corresponds to a percentage value of reliability. By adopting one of the values generated by the simulation for the average cost of care as a value to be charged to users, it will be known how likely this revenue will be to honor the care expenses that will occur in the future. As an example, the value is R$ 78.41, 27.005, which is the highest value, below only approximately 3,000 values, that is, 10% of the 30,000 values generated. In this way, it can be said that, in approximately 90% of the occasions, the average care costs to occur will be less than or equal to R$ 78.41.

Figure 5. Graph of ordered simulated values
Source: Own research

The value adopted as price will be valid for one year, and the choice and determination of an appropriate adjustment mechanism is very important. With the passage of the months, the assistance costs, navigating the market, undergo the natural inflationary process. The ANS regulates the maximum annual adjustment, after the contract year has elapsed. Thus, in order to face the risk of the adjustment allowed by the ANS to be lower than the inflation that actually occurs, a Δvalue must be added to the initially adopted price. As a simplifying premise, future monthly inflation was assumed to be constant at 0.1876% am., focusing on costs. The remaining balance of the differences between the care costs and the estimated costs will be adjusted to an active interest rate of 1% am.. The value chosen to represent the

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care costs at time zero will be R$ 78.41. With this, it is seen that the lowest assistance price that can be charged is R$ 79.21 if the decision maker wishes to work with 90% confidence (Table 1).

In the first line, one has the constant monthly assistance price. In the second line, the expected average care costs occur every month. In the third line, we have the differences between the values of line 1 and the values of line 2. And, to conclude, in the fourth line, we have for each value the balance of the previous period, capitalized at 1%, plus the value of line 3.

Subsequently, two new simulations were carried out, generating 30,000 variants of average care costs for portfolios with 1,000 and 10,000 clients, ceteris paribus. With the experience, it was possible to verify that the amplitude, difference between the maximum value and the minimum value, obtained with the simulation for approximately 114,000 users, was lower than that obtained for 1,000 users. With the same minimum care cost of R$ 78.41, the confidence level in the simulation for 10,000 users was 67.94% versus 90% for the simulation to approximately 114,000 users.

To obtain the 90% confidence level, we need to choose the amount of R$ 78.41 for 113.359 users, R$ 85.02 for 10,000 users and R$ 101.97 for 1,000 users. Considering that the minimum care price to be charged by a portfolio with 113,359 users, in order to obtain a probability of 90% of the costs incurred is lower than the price charged, is R$ 79.21, for a portfolio with 10,000 users, it should be charged an 8.43% higher amount; and, for a portfolio with 1,000 users, one should charge a 30.05% higher value, as shown in Table 2.

6. FINAL CONSIDERATIONS

It can be seen that in a decision-making process, there are several factors that significantly influence the final outcome of this process. In the case of the on-screen study, that is, the determination of the average care cost, the number of clients in the portfolio, the care costs related to each user and the level of confidence desired are the factors that should be considered most important.

Simulation is a flexible and widely used tool to estimate the behavior of stochastic systems. The health area is among the possible fields of application of the Monte Carlo Simulation.

It is understood that the objective of the study was successfully achieved, namely, to show a simplified procedure for the determination of per capita assistance costs and the importance of the size of the insured group for the technical solvency charge, a direct consequence of the Law of Great Numbers, first described by Jakob Bernoulli. It is also understood that there was collaboration with decision-makers, active in the area of supplementary health, regarding the determination of the cost of care, a component of the price to be charged by a health plan.

In this sense, this study obtained a result that, as in other studies that also used simulation (Di Giorgio et al., 2016, Paulo et al., 2017, Silva et al., 2015), can be considered as a good tool to assist managers in managing organizations' financial resources through their procedure.

	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Care price (A)	79,21	79,21	79,21	79,21	79,21	79,21	79,21	79,21	79,21	79,21	79,21	79,21
Expected Costs (B)	78,41	78,56	78,7	78,85	79	79,15	79,3	79,45	79,59	79,74	79,89	80,04
Dif. (A-B)	0,8	0,65	0,51	0,36	0,21	0,06	-0,09	-0,24	-0,38	-0,53	-0,68	-0,83
Balance	0,8	1,46	1,98	2,36	2,59	2,68	2,62	2,41	2,05	1,54	0,87	0,04

Table 1. Calculation value charged

Source: Own research

Portfolio Size	**113.359 Users**	**10.000 Users**	**1.000 Users**
Maximum value	R$ 85,15	R$ 116,62	R$ 252,24
Minimum value	R$ 68,78	R$ 55,24	R$ 40,35
Maximum - minimum	R$ 16,38	R$ 61,38	R$ 211,89
Trust for value R$ 78,41	90%	67,94%	66,24%
Value for 90% confidence	R$ 78,41	R$ 85,02	R$ 101,97
Reset value	R$ 79,21	R$ 85,89	R$ 103,01
% var. in relation to R$ 79.21	0,00%	8,43%	30,05%

Table 2. Impact of health plan portfolio size

Source: the research

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