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Pricing of health plans: An efficiency analysis of different calculation methodologies

Precificação de planos de saúde: Uma análise de eficiência de diferentes metodologias de cálculo

Tarificación de planes de salud: Un análisis de eficiencia de diferentes metodologías de cálculo

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ABSTRACT
Over the last 20 years, the Supplementary Health Market has seen a reduction in the number of Health Companies due to insolvency. There are several risks that can lead to this factor, and one of the main ones is the pricing risk. With this in mind, the present study sought to analyze the efficiency of different methods in calculating the pricing of supplementary health plans. To carry out the pricing, Monte Carlo simulation methods, Collective Risk Theory and Credibility Theory were used. The study found that the Credibility Theory showed the greatest efficiency for calculating the pricing of health plans, among the three methods analyzed, for the sample used.
Keywords: health supplement; Monte Carlo simulation; Collective Risk Theory; Theory of Credibility; Actuarial Sciences.

RESUMO
O Mercado de Saúde Suplementar tem apresentados ao longo dos últimos 20 anos uma redução no número de Operadoras de Saúde devido à insolvência. Existem vários riscos que podem levar a esta realidade e um dos principais é o risco de precificação. Tendo isto em vista, o presente estudo buscou analisar a eficiência de diferentes métodos no cálculo de precificação de planos de saúde suplementar. Para realizar as precificações foram utilizados os métodos de simulações de Monte Carlo, Teoria do Risco Coletivo e Teoria da Credibilidade. O estudo constatou que a Teoria da Credibilidade apresentou a maior eficiência para os cálculos de precificação de planos de saúde, dentre os três métodos analisados, para a amostra utilizada.
Palavras-chave: saúde suplementar; simulação de Monte Carlo; Teoria do Risco Coletivo; Teoria da Credibilidade; Ciências Atuariais.

RESUMEN
En los últimos 20 años, el Mercado de Salud Complementaria há visto una reducción en el número de Operadores de Salud debido a la insolvencia. Hay varios riesgos que pueden conducir a este factor, y uno de los principales es el riesgo de precio. Con esto en mente, el presente estudio buscó analizar la eficiencia de diferentes métodos en el cálculo de la tarificación de los planes de salud complementarios. Para llevar a cabo la tarificación se utilizaron los métodos de simulación de Montecarlo, la Teoría del Riesgo Colectivo y la Teoría de la Credibilidad. El estudio encontró que la Teoría de la Credibilidad mostró la mayor eficiencia para calcular el precio de los planes de salud, entre los tres métodos analizados, para la muestra utilizada.
Palabras clave: salud suplementaria; simulación del Monte Carlo; Teoría del Riesgo Colectivo; teoría de la credibilidad; Ciencias Actuariales.

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1 INTRODUCTION

According to the Brazilian Constitution, "health is the right of all and the duty of the State", but the Unified Health System (SUS) has been facing problems in its network of services and remuneration of its employees (Figueiredo, 2021). As a result, the search for supplementary health plans has been strengthening, thus realizing the great need for this branch (Paim, 2018).

The supplementary health market, which refers to the operation of private health care plans, began its development in Brazil in the 1960s and since then has always been growing (Cella, 2019). In December 2000, approximately 30.9 million beneficiaries were covered by health care plans, of which about 13.8 million were related to collective business plans (ANS, 2022). Already in relation to December 2021 can be verified an increase of approximately 60% of beneficiaries, totaling 48.9 million beneficiaries, of which 33.6 million came from Corporate Collective plans (ANS, 2022). Despite this, the Brazilian population that is covered by Supplementary Health plans represents only 22.98% of the total estimated by the Brazilian Institute of Geography and Statistics (IBGE) in December 2021.

Even with the growth in the number of beneficiaries in the supplementary health market, the number of Health Care Plan Providers (HCPP) decreased over the years, from 2,037 medical-hospital Companies in operation in December 2000 to 696 in June 2022 (ANS, 2022). Insolvency is considered one of the main reasons for the reduction in the number of OPS in the last 20 years, due to the trend of growth in sinistrality (Araújo & Silva, 2018). The explanation for this phenomenon in the supplementary health market does not focus on just one cause, but on several factors together that decrease the revenues of companies and promote the increase of care costs. Among these causes, the demographic transition, readjustment of tuition fees below the necessary and inadequate pricing of health care plans (Sá, Maciel & Reinaldo, 2017). In this context, it can be seen that insolvency is conditioned to various risks, in particular actuarial risks.

Actuarial risk management aims to ensure the standards of economic and financial security, with specific purposes of preserving the liquidity, solvency and balance of plans (PREVIC, 2012). From an eminently actuarial perspective, the risk that most strongly impacts the mathematical models used in actuarial calculations and projections is underwriting risk (ANS, 2022). According to Normative Resolution No. 451 of March 6, 2020, underwriting risk is the measure of uncertainty existing in the estimation of technical provisions and pricing. Therefore, the pricing risk is shown as one of the biggest risks of the operator (Altieri, Melo & Veiga, 2013; Chan, 2010).

There are several methods for calculating the pricing of consideration of health plans, however, in general, these consider frequency of use and average cost (Dourado, 2020). From this data it is possible to make several simulations, scenarios and validations of the assumptions used. However, there are other methodologies that are not commonly used in the supplementary health market and can present efficient results regarding the projection of care costs and, consequently, pricing (Bueno, 2017). In this context, one can cite the Monte Carlo simulation method and the Credibility Theory.

Given this context, the present study presents as general objective to analyze the efficiency of different methods in the calculation of pricing of supplementary health plans. For this, the following specific objectives were established: to compare the efficiency of the projection of care costs among the methods of pricing of health plans used, to analyze the sensitivity of each methodology to adverse scenarios and to identify the main advantages and disadvantages in the application of each method.

This research is justified by the importance of the supplementary health market in Brazil, in addition to the high-risk present in the business. Recently, the Senate approved the bill No. 2033/2022 that changes the ANS list from exhaustive to exemplary, that is, Companies are now required to cover procedures outside the list of ANS, which makes the work of the actuary in relation to risk estimation and pricing of health plans even more complex. Therefore, identifying the pricing model with better efficiency can contribute to the sustainability of Companies.

The present study is divided into 5 sections, the first of which is composed by the present introduction. The second section briefly discusses the history of evolution of the supplementary health market and fundamental concepts about pricing of health plans. The third section presents the steps developed to carry out this research. The fourth section demonstrates and discusses the results obtained and, at the end, we have the final considerations of the study.

2 THEORETICAL REFERENCE

This section briefly discusses the history of evolution of the supplementary health market and fundamental concepts about pricing of health plans.

2.1 Supplementary Health Market in Brazil

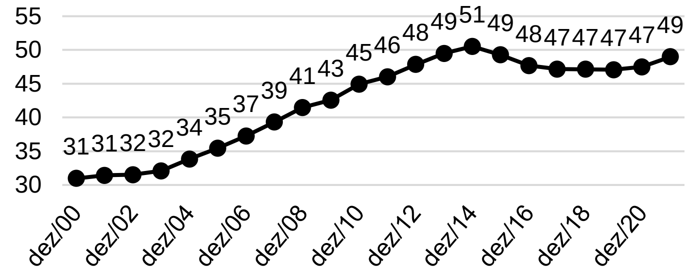
The origin of the private health system in Brazil dates back to around the 1920s and 1930s, when the first health care programs for workers appeared (Salgado, 2018). The chronology of the organization of health Companies is dated from the 1960s through the foundation of the first operator in the modality of group medicine based in the ABC region of São Paulo and the first medical cooperative founded in the city of Santos (Cata Preta, 2004).

Despite the existence of HCPP in the 1960s, the supplementary health sector still did not have specific regulations. Only in 1998, with the enactment of Law No. 9,656, which provides for private health care plans and insurance, the regulatory process of private supplementary care began. Subsequently, through Law No. 9,961, of

January 2000, there was the creation of the National Agency for Supplementary Health (ANS), called as a regulatory, standardization, control and inspection body of activities that guarantee supplementary health care (Brasil, 2000). After the regulatory framework of the supplementary health market, there was a significant growth in the number of beneficiaries of health plans until December 2014, when a slight decrease was identified, followed by a new period of growth (ANS, 2022) as can be seen in Graph 1.

Graph 11

Number of beneficiaries of private health plans in Brazil (in millions)

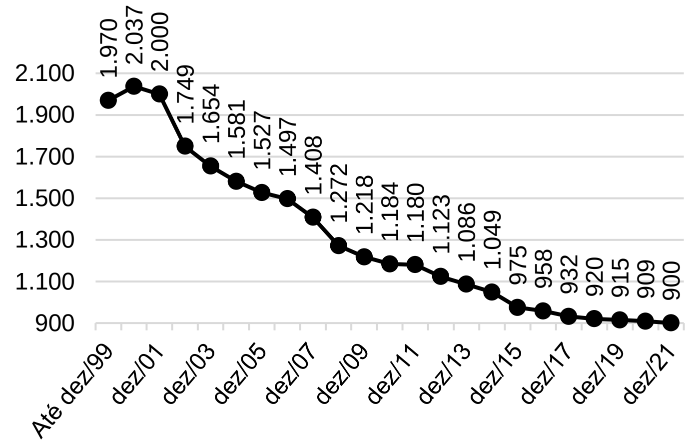


Source: Adapted from ANS (2022).

Below, in Graph 2, we can analyze the evolution of the number of private health plan Companies in activity from December 1999 to December 2021. An inverse behavior is perceived to the number of beneficiaries, presenting a growth in the year 2000, and after a reduction year after year (ANS, 2022).

Graph 22

Private health plan Companies operating in Brazil



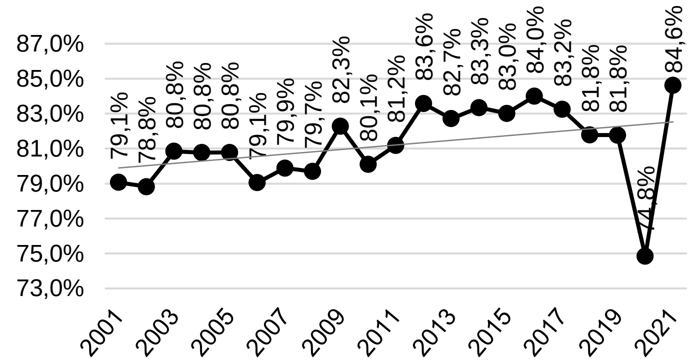
Source: Adapted from ANS (2022).

The number of beneficiaries of private health plans had a large increase, from 31 million in December 2000 to 49 million in December 2021 in health care plans with or without dentistry. This absolute increase represents an increase of 58% over a 21-year period. The number of private health plan Companies had a continuous decrease, from 1,970 Companies in December 1999 to 900 in December 2021. This absolute decrease represents a 46% drop in the number of HCPP in activity in Brazil.

The high accident rate represents one of the main reasons for the insolvency of Health Plan Companies in Brazil (Araújo & Silva, 2018). Graph 3 shows the evolution of sinistrality in private health plans over the years. A smaller oscillation can be verified between the years 2011 to 2019, comparing the oscillation observed in the years 2020 and 2021, when there is a significant drop in the year 2020, due to the social isolation measures established in the face of the COVID-19 pandemic, and, in the year 2021, it is possible to verify the return of uses, this being the year with the highest accident rate since 2001.

Graph 33

Claims of health plan Companies in Brazil



Source: Adapted from ANS (2022).

In this context of growth in sinistrality, actuarial risk management is of paramount importance to ensure the standards of economic and financial security, with specific purposes of preserving the liquidity, solvency and balance of plans (PREVIC, 2012). From an actuarial perspective, the risk that most strongly impacts the mathematical models used in actuarial calculations and projections is underwriting risk (ANS, 2022). According to Normative Resolution No. 451 of March 6, 2020, underwriting risk is the measure of uncertainty existing in the estimation of technical provisions and pricing. Therefore, the pricing risk is shown as one of the biggest risks of the operator (Altieri, Melo & Veiga, 2013; Chan, 2010).

2.2 Efficiency

Efficiency can be defined as a virtue or characteristic of being competent, productive, of achieving the best performance with the least number of errors. According to Mendes (2015), efficiency is defined as the relationship between goods and services generated by an activity and the costs of the inputs used to produce them, in a given period of time, maintaining quality standards. It can be measured by calculations and comparing them to the unit cost of producing a good or service. The concept of efficiency, therefore, is related to that of economy.

For Castro (2018), the Concept of efficiency is related to the use of available resources to achieve a certain expected result, it can be the comparison between what is predicted and what is executed. Using a company as an example, which wants to achieve the cost / benefit of a particular product, but maintaining the high level of that manufactured product, that is, optimize, and this optimization can be financial, production, technology used, employee training or even the exchange of materials used. Another example would be a city hall that the taxpayer opens administrative proceedings in a physical way, that is, attending the place. A more efficient way would be the opening of electronic processes, through official websites or e-mail, this procedure would be efficient for accessibility, practicality and speed, in addition to the economy of materials used.

Marinho and Façanha (2001) say that the definition of efficiency is established by the relationship between the inputs of goods and services and the outputs that are the final results coming from an organizational process. The efficiency of an activity is very much related to its productivity. As the focus of efficiency is, in this view, between inputs and outputs, there is the implication of eliminating unnecessary waste and consumption in order to rationalize resources.

In this article the concept used will be that of Castro (2018).

According to the authors mentioned above, these concepts can be applied in the health area in two areas. The first of them, is within the internal management of the company. In this sphere all the inputs of the company are analyzed, that is, the workforce, the human capital, the software used, the team of employees and the suppliers, and also the outputs, which are what is delivered from these inputs, that is, the services provided in the health plans.

The second area that can be done the application of this concept of efficiency, is the concept of business. We analyze the inputs from the revenues, the premium payments of the insured. Already the outputs are analyzed from the costs, the expenses the use of the health plan. This difference will generate a gross margin that can be analyzed in terms of the efficiency of the company, and as to the objectives that must be achieved, proposed profit margins, the degree of risk assumed, the minimum required return on capital.

The scope used in this article was the second, from an analysis in terms that aim to look at the results brought here that can be reflected in the financial results, to then perform the analyses are proposed in this study. Therefore, this efficiency term will be applied at the business level of the area of health Companies.

2.3 Risk of underwriting and pricing of health plans

Altieri, Melo and Veiga (2013) brings in detail the division of underwriting risk and its definition based on the concepts applied by the Association *of Insurance Supervisors* (IAIS) and *International Actuarial Association* (IAA), which define the underwriting risk to specific insurance arising from the underwriting of insurance contracts. In turn, the report of the IAA working group (2004), in section 5.24, states that the risks that make up the category of underwriting risks are those related to the "dangers" covered by the different insurance coverages, as well as those related to the specific processes associated with the conduct of the insurance business. The generic risks that may be included in the underwriting risk are:

- Underwriting Process – risk of exposure to financial losses related to the approval and selection of risks to be insured;
- Product Design – danger that the company will be exposed to risks, arising from the insurance contracts signed, which were not anticipated when designing and pricing such contracts;
- Claims – risk that many more claims will occur than expected or that some claims will be much larger than expected, resulting in unexpected losses;
- Economic Environment – risk that economic conditions change in such a way that they will have an adverse effect on the company;
- Net Retention – risk that large withholdings of insurance-covered risks result in losses due to the experience of catastrophic or concentrated claims;
- Insured Behavior – risk that the company's insured will act in unforeseen ways, producing an adverse effect on the company;
- Reserve – risk that the provisions set out in the financial statements (specifically the provisions relating to claims incurred) are inadequate;
- Pricing – risk that the prices determined by the companies for the insurance contracts signed will be inadequate to support the future obligations arising from such contracts (Williams & Sant'anna, 2010).

According to a study published by the Pan American Health Organization (PAHO) in partnership with the National Agency for Supplementary Health (ANS) and the Ministry of Health (MS), when pricing a health plan, Companies have expectations about who the potential consumers are, when and how they will use the contracted coverage, how long they will keep their contracts and what services will be covered. Therefore, the risk that these expectations will not materialize and the risk that the results will be worse than expected is part of the pricing risk. Using a more formal definition, pricing risk is the risk that adverse economic conditions will be contrary to social expectations when underwriting policies are developed (PAHO, ANS, & MS, 2021).

Since pricing risk is an important part of the underwriting risk and risk-based capital of HCPPs, it can be defined as the probability of the operator's future care cost exceeding the revenue from consideration received, due to an unexpected or different behavior from what was considered at the time of pricing (PAHO, ANS, & MS, 2021). Given this context, defining the premises that approach the reality of the profile of the beneficiaries of the plan and using an efficient pricing methodology contributes to mitigate the pricing risk of the HCPP and ensure its continuity.

2.4 Related studies

Corrar (1998) analyzed how the Monte Carlo magnetization m is useful in the treatment of one of the important aspects of decision analysis, which is uncertainty modeling. The basic concepts of simulation and the Monte Carlo method were presented. The Monte Carlo simulation technique was applied in a Foundation that takes care of the health care of employees of several companies. Through the results presented it was possible to make projections of costs related to the health plans of these companies as well as to determine the risks associated with these projections, concluding that the simulation technique can be of great use in the decision-making process by the administration.

Lemenhe et al. (2006) aimed to present a procedure for determining the future behavior of the monthly care cost per user regarding the use of individual plans based on historical data, through the Monte Carlo simulation technique and statistical regression. The procedure was presented by determining the behavior of the dependent variable for the age group between 0 and 18 years. In conclusion, they identified that the Monte Carlo simulation is an important instrument, as it can supply the decision maker with precious information so that he can form a more comprehensive picture of the situation before deciding. With the use of the tool, the decision maker will be aware of the range of the cost function, as well as the probability of occurrence of this information. Macêdo, Capelo and Lopes (2018) aimed to show a simplified procedure for determining per capita care costs and also to show the importance of the size of the insured group for the technical loading of solvency. For this purpose, historical data were used through the Monte Carlo Simulation technique. The data are real and were obtained from a health operator in the city of Fortaleza. In practical terms, this study collaborated with the decision makers, active in the area of supplementary health, with regard to the determination of the portion of care cost, a component of the price to be charged by a health plan.

Dias, Baltazar and Lumertz (2021) developed a calculation method for the percentage of readjustment from the Credibility Theory. For this, data from a large health operator were used. In the study, it was concluded that the average sinistrality per contract would be lower than the observed sinistrality, allowing us to infer that the proposed method proved to be adequate, because, in addition to being coherent and presenting a statistical and actuarial basis, it allows a satisfactory calculation of the readjustment. As limitations, the study used a historical database referring to 12 months, which may impact the efficiency of the statistical prediction model due to the scenarios of high variability and unpredictability.

Paiva et al. (2021) sought to verify the impact of co-participations on the projections of sinistrality of medical cooperatives in Brazil. To perform the scenario projections, Monte Carlo simulations were used based on data from the ANS and the Institute of Supplementary Health Studies for five years, from 2015 to 2019. For comparison purposes, firstly, projections were made without considering the recovery values by co-participation and, subsequently, projections that considered these recoveries. The study found that there is a significant financial and statistical impact on the reduction of accident rates when the mechanism of co-participation in the Health Plans of this sector is used, as well as evidenced the efficiency of the Monte Carlo method for these projections.

The present study is relevant because it seeks to analyze the efficiency between different models of pricing of health plans, using historical data as a basis for the calculations and comparing them with the actual results obtained in the following period. In this way, it will be possible to identify which model contributes to the best result of the HCPP. In addition, as the period under review comprises the Covid-19 pandemic, it will be possible to identify which model presented the best estimate in the face of an adverse scenario.

3 METHODOLOGICAL PROCEDURES

In this section will be presented the classification of the research, the description of the collection and sample of data and how these were analyzed. Regarding the classification of the research, it is classified according to the following aspects: (a) by the way the problem is approached, (b) according to its objectives and (c) based on the technical procedures used.

3.1 Research classification

Regarding the way of approaching the problem, from statistical methods with the objective of answering the problem question, this study is framed as quantitative research. Quantitative research tends to emphasize deductive reasoning, the rules of logic, and the measurable attributes of human experience, using mathematical and statistical methods in its analyses (Gerhardt & Silveira, 2009).

As for the objectives of this research, it is classified as explanatory, since it will seek to analyze the efficiency between methods of pricing of health plans. The explanatory research seeks to identify the causes of the phenomena studied, in addition to recording and analyzing them, both through the application of experimental and mathematical or qualitative methods (Gil, 2018).

With regard to the technical procedures used, this study is characterized by being documental, since private files made available by a given OPS were used, which consist of information related to costs, revenues and number of beneficiaries per period of a specific plan. The documentary research has the source of data collection restricted to documents, written or not, classified as primary sources (Marconi & Lakatos, 2003).

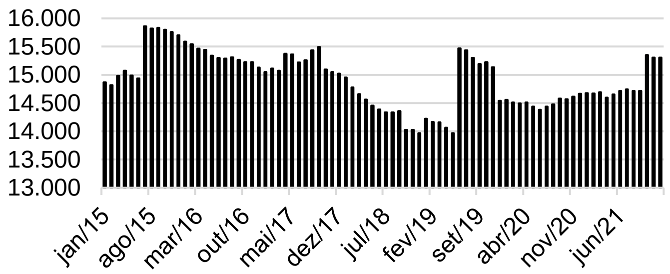
3.2 Sampling and data collection

The sample used in this study includes approximately 15 thousand lives, from a business plan, with outpatient and hospital coverage with obstetrics, collective accommodation, with co-participation and geographical coverage by group of municipalities, of a cooperative of health plans in the state of Rio Grande do Sul. The data collected refer to the number of beneficiaries, care costs and consideration revenues.

The data for analysis were extracted from the QlickView software, made available by the health operator in question, extracted in July 2022 and referring to the period from 2015 to 2021. The data used includes the Covid-19 pandemic, reflected in the data for the years 2020 and 2021. We chose to include this period in order to analyze the impact of moments of abnormality in the health area.

As Macêdo, Capelo and Lopes (2018) pointed out in their final considerations, there is a great importance in relation to the size of the group of insured to meet the requirements of the Law of Large Numbers, thus, it can be seen in the following graph that the sample size used in the work, in no period, was less than 13,500 lives.

Graph 4
Sample size



Source: Prepared by the Authors.

3.3 Data analysis

Based on the available data, pricing was developed with three different methods. The pricing always considered the information referring to a period of 12 months and compared with the data of the following 12 months, that is, the prices developed with the data of the year 2015 were compared with the data of costs observed in 2016 and so on. Therefore, it was possible to observe whether the monthly fee calculated was sufficient to cover the identified care costs. In addition, it was possible to compare the methods in order to identify which presented the best estimate. It is noteworthy that the prices were not segmented by age groups and the type of care cost as defined in RN No. 564/2022, considering only the average cost per beneficiary. The methods chosen for this study were: a) Collective Risk Theory; b) Monte Carlo simulation; c) Credibility Theory.

3.3.1 Collective Risk Theory

In the collective risk model, the distribution of claims of a portfolio as a whole is considered, without worrying about the characteristics of the claims produced by each individual, as happens in the individual risk (Ferreira, 2010). According to Ferreira (2010), the Collective Risk Theory has:

$$E[S] = E[N]\ .\ E[X]$$

Where:

$E[S]$ = the value of the expected loss or aggregate claim;

$E[N]$ = the expected number of claims or frequency;

$E[X]$ = the expected value for a claim or severity.

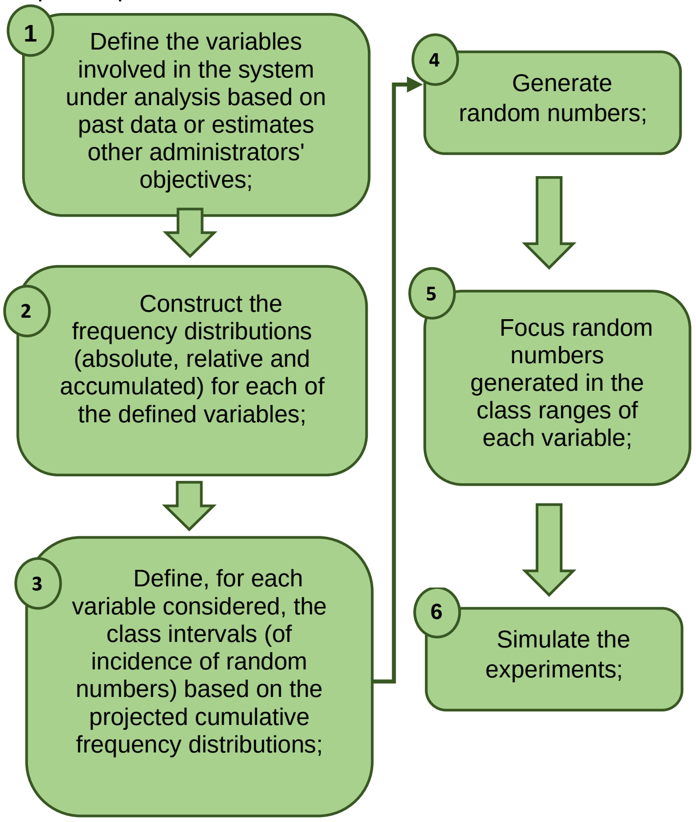
For the use of the Collective Risk Theory in this research, we considered the frequency of use of the period under analysis and the average cost per claim to calculate the expected loss for the following period, that is, the average cost per beneficiary.

After calculating the E[S], the value obtained was updated for the next period considering as an indicator for monetary update the IPCA accumulated in December of each year. Finally, the necessary loads were applied on the calculated costs, for a target sinistrality of 70%.

3.3.2 Monte Carlo simulation

The goal of Monte Carlo simulations is to generate random numbers that determine an artificially drawn sample of a variable from which estimates are calculated (Hammersley & Handscomb, 1964). According to Saraiva, Tabosa and Costa (2011), the basic steps that must be followed in a Monte Carlo Simulation are:

Figure 1
Steps for operationalization of the Monte Carlo simulation method



Source: Adapted from Shamblin and Stevens (1974).

10,000 simulations were performed, considering this a satisfactory number, since the minimum number of simulations calculated for this study was 4,055, considering the formulation defined by Bueno (2017):

$$n > \frac{Z_{\alpha/2}.\tau^2}{\varepsilon^2}$$

Where:

n = number of simulations;

$Z_{\alpha/2}$= confidence level, which is 95%;

τ = variance observed in the claims of the analyzed period;
ε = average observed in the claims of the analyzed period.

In this study, the input variables of the model were the care cost, the total number of beneficiaries and the total number of beneficiaries with use and as exit or dependent variables the average monthly cost per beneficiary with use (severity) and the frequency of use. Through the parameters, a random sample with 10,000 elements was generated to create scenarios of average care cost per beneficiary. To perform the simulations, the *Microsoft Excel software* (Version 2019) was used.

Simulations of frequency and severity were developed for each year, with the average cost per beneficiary defined by the product between frequency and severity. For the frequency simulations, a binomial distribution was considered. Por if it is a statistical distribution for discrete random variables, the frequency of claims can be easily estimated through this (Bueno, 2017). The parameters used in the binomial distribution are n and p, where n represents the number of beneficiaries of the health plan and p the probability of use. For the severity simulations, a gamma distribution was considered, since it presents a good adherence to obtain the care cost (Malehi, Pourmotahari, & Angali, 2015).

Subsequently, the average cost was calculated, considering this as the product between the frequency and severity of each scenario and, then, the value obtained was updated for the next period considering as an indicator for monetary update the IPCA accumulated in December of each year. Finally, the necessary loads were applied on the costs calculated to obtain the commercial premium, with a target sinistrality of 70%.

3.3.3 Credibility Theory

The Credibility Theory represents a systematic way of calculating insurance rates as the claims experience becomes available (Bueno, 2017). The solution defended by the Credibility Theory is the use of experiences of similar risks or identical risks referring to the experiences of previous periods, these experiences combined with the most recent experience of the risk to be priced (Ferreira, 2010). The way of calculating the risk premium by the Credibility Theory is as follows:

$$P_C = Z.P_D + (1 - Z).P_A$$

Where:
P_C = total risk premium calculated by the Credibility Theory;
P_D= total risk premium of the experience obtained by the insurer;
P_A = total risk premium of the additional experience to be combined with the insurer's experience;
Z = credibility factor, with a value between 0 and 1, which is determined from direct and additional experiences.

The data referring to the were obtained from the ANS website, considering the information of average cost per beneficiary identified in the market, referring to collective health plansP_A, with outpatient and hospital coverage with obstetrics, collective accommodation, with co-participation, of medical cooperatives in Brazil, thus following the same premises previously used in this study. The data are available on the ANS Tabnet.

To calculate the credibility factor, it is first necessary to calculate the minimum number of claims in the portfolio in order to have total credibility, as demonstrated by Ferreira (2010):

$$\lambda_m = \left(\frac{Z_{1-\alpha/2}}{K}\right)^2 . \left(1 + \left(\frac{\sigma[X]}{E[X]}\right)^2\right)$$

Where:
λ_m = minimum number of claims for total credibility;
$Z_{1-\alpha/2}$ = confidence level, being considered 95%;
K = accepted error between the estimated risk and the observed risk, being considered 1%;
$\sigma[X]$ = standard deviation of claims for the period analyzed;
$E[X]$ = average of the claims of the analyzed period.

Obtaining the λ_m it is possible to calculate the credibility factor Z with the following formulation:

$$Z = \sqrt{\frac{\lambda}{\lambda_m}}$$

Where λ corresponds to the expected number of claims, being calculated as the product between the number of beneficiaries and the frequency of use observed in the period. After calculating Z, the prize for the Theory of Credibility was estimated. Subsequently, the value obtained was updated for the next period considering as an indicator for monetary update the IPCA accumulated in December of each year. Finally, the necessary loads were applied on the calculated costs, for a target sinistrality of 70%.

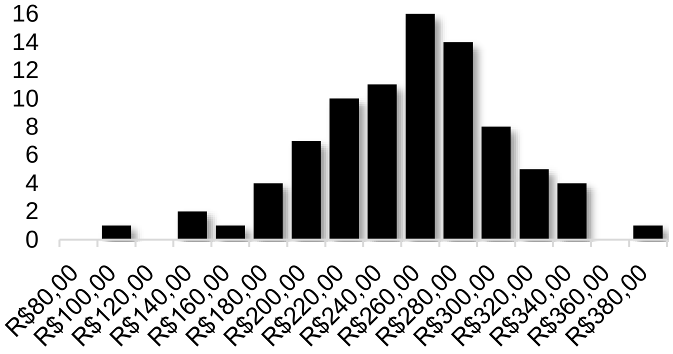
4 DATA ANALYSIS AND DISCUSSION

This section presents the analyses carried out in this study seeking to achieve the objective of the research. First, the values and distributions of the average care cost per beneficiary with use in each year will be presented, as well as the frequency of their use. Following are presented the results obtained in each method and, at the end, a comparative analysis is developed between them.

4.1 Descriptive analysis

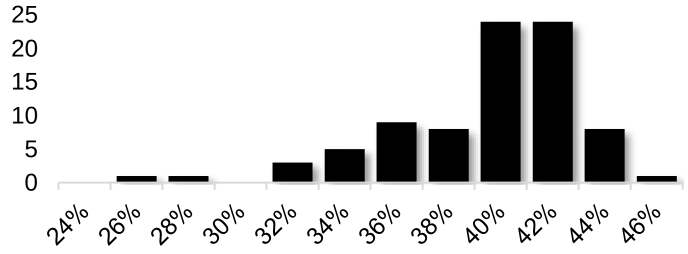
The databases used show the number of total beneficiaries of the chosen product. The average observed in the period from 2015 to 2021 was 14,918 monthly beneficiaries and, of these, 5,731 with utilization. The average frequency of use was 38.4% and the monthly aggregate claim per capita was R$ 244.40. Dias, Baltazar and Lumertz (2021) suggested the use of a database with longer historical periods, as was done in this study, since the authors worked only with the year 2020. The Graphs 5 and 6 show the distribution of the average monthly cost and frequency observed in the period corresponding to the six years analyzed.

Graph 5
Distribution of the monthly assaulted claim in the period (% x R$)



Source: Prepared by the Authors.

Graph 6
Frequency Distribution in the Period (% x %)



Source: Prepared by the Authors.

Analyzing the results of each year individually, the mean severity was calculated, that is, the average cost of the beneficiaries who presented use of the plan and the frequency of use, as well as the standard deviation of these variables.

Table 11
Severity and Frequency per year

		2015	2016	2017	2018	2019	2020	2021
Severity	**Average**	R$ 485.69	R$ 540.33	R$ 589.90	R$ 643.98	R$ 632.32	R$ 782.59	R$ 801.14
	Standard deviation	R$ 95.32	R$ 48.10	R$ 43.43	R$ 43.61	R$ 35.56	R$ 36.58	R$ 36.93
Frequency	**Average**	38.00%	38.63%	39.52%	39.82%	40.81%	33.94%	38.16%
	Standard deviation	3.04%	2.66%	2.23%	2.25%	2.36%	2.37%	2.52%

Source: Prepared by the Authors.

There is an increase in the average cost over the years, showing a sharp growth in 2020, even though, in the same year, the lowest frequency of use was registered, due to the pandemic scenario.

4.1 Collective risk theory

For the calculation by the Collective Risk Theory, the variables were considered $E[X]$, that is, the average value of a claim and $E[N]$, the expected number of claims or frequency. As already mentioned earlier, one can notice the steady increase in the aggregate claim each year. Attendance is also on the rise, with a sharp drop in 2020 due to the COVID-19 pandemic. The Table 2 shows these values for each year.

Table 22
Variables used in the calculation by the Collective Risk Theory

	2015	2016	2017	2018	2019	2020	2021
***E* [X] (R$):**	485.69	540.33	589.90	643.98	632.32	782.59	801.14
***E* [*N*]:**	38.00%	38.63%	39.52%	39.82%	40.81%	33.94%	38.16%

Source: Prepared by the Authors.

Below are shown the projected costs from the Collective Risk Theory, the premiums calculated for a target sinistrality (TS) of 70%, the observed costs and the sinistrality obtained for each year from the previous calculations.

Table 33
Results from the Collective Risk Theory

Data/ Projected year	Projected Cost (R$)	Calculated Premium (R$)	Observed Cost (R$)	Sinistrality	TS (70%) - S
2015/2016	204.26	291.79	208.72	71.53%	-1.53%
2016/2017	221.85	316.92	233.13	73.56%	-3.56%
2017/2018	240.00	342.86	256.41	74.79%	-4.79%
2018/2019	266.03	380.04	258.02	67.89%	2.11%
2019/2020	269.14	384.49	265.63	69.09%	0.91%
2020/2021	277.64	396.63	305.75	77.09%	-7.09%

Source: Prepared by the Authors.

The premium values calculated from the Collective Risk Theory were close to the target sinistrality in all years, with the smallest difference in 2020 and the largest difference in 2021. When analyzing the average difference of the target accident rate in relation to the accident rate obtained in the period, the value of -2.33% is obtained, indicating a sinistrality in the six-year period of 72.33%.

There is a favorable result for the first year of the Covid-19 pandemic, but when analyzing the second year of the pandemic, which was based on the year 2020, the results were not so positive. The pandemic that began in the year 2020, as previously mentioned in this study, caused an increase in care costs, but a significant reduction in frequency, and this may be the cause of the unsatisfactory result for the year 2021, as well as the favorable result of 2020. The main advantage of applying this method for the pricing of health plans is the simplicity of the calculation, since it considers only the product between the variables of severity and frequency.

4.2 Monte Carlo simulation

To perform the calculation from the Monte Carlo simulations, two samples were generated simulating 10,000 possible scenarios per year using a binomial distribution for frequency and a gamma distribution for average cost, based on the results obtained by Malehi, Pourmotahari and Angali (2015), who demonstrated that the distribution presented a satisfactory behavior for care costs. Below are shown the projected costs from the Monte Carlo simulations, the premiums calculated for a target sinistrality (TS) of 70%, the observed costs and the sinistrality obtained for each year from the previous calculations.

Table 4

Results of Monte Carlo simulations

Year	Projected Cost (R$)	Calculated Premium (R$)	Observed Cost (R$)	Sinistrality	TS (70%) - S
2016	223.75	319.64	208.72	65.30%	4.70%
2017	230.55	329.36	233.13	70.78%	-0.78%
2018	239.53	342.19	256.41	74.93%	-4.93%
2019	246.10	351.57	258.02	73.39%	-3.39%
2020	257.75	368.21	265.63	72.14%	-2.14%
2021	276.03	394.33	305.75	77.54%	-7.54%

Source: Prepared by the Authors.

The premium values calculated from the Monte Carlo simulations were close to the target sinistrality in all years, with the smallest difference in 2017 and the largest difference in 2021. When analyzing the average difference of the target accident rate in relation to the accident rate obtained in the period, the value of -2.35% is obtained, indicating a sinistrality in the period of six years of 72.35%.

This method proved to be efficient for the first year of the covid-19 pandemic, but when we analyze the second year of the pandemic, which was based on the year 2020, the results were not so positive, which may have as an influence the considerable change in the behavior of the beneficiaries of the plan in this period. The main advantage of the application of this method for the pricing of health plans is the possibility of generating several scenarios associated with their respective probabilities of occurrence. As a disadvantage, the method presents greater complexity in its execution, with the need to initially identify the best statistical distribution for the severity and frequency variables, simulate a number of satisfactory scenarios and calculate the probability values for each scenario. In addition, a more in-depth knowledge of the *software* that will be used is required.

4.3 Credibility Theory

For the calculation by the Credibility Theory, the variables PD (total risk premium of the experience obtained by the insurer), PA (total risk premium of the additional experience to be combined with the experience of the insurer), λm (minimum number of claims for total credibility), λ (expected number of claims) and Z (credibility factor) were considered. The following table shows the values used for each of the variables mentioned above for each year.

Table 5

Variables used in the calculation by the Credibility Theory

	2015	2016	2017	2018	2019	2020	2021
PD (R$):	184.56	208.72	233.13	256.41	258.02	265.63	305.75
PA (R$):	190.31	212.77	237.16	276.32	313.71	291.96	342.35
λm:	39,928.2	38,719.9	38,754.9	38,805.7	39,288.2	39,288.6	38,682.8
λ:	15,368.6	15,342.0	15,211.0	14,402.8	14,739.2	14,518.7	14,843.7
Z:	0.620	0.629	0.626	0.609	0.612	0.608	0.619

Source: Prepared by the Authors.

Table 6 shows the per capita costs projected from the Credibility Theory, the premiums calculated for a target sinistrality of 70%, the observed costs and the sinistrality obtained for each year from the previous calculations.

Table 6
Results from the Theory of Credibility

Year	Projected Cost (R$)	Calculated Premium (R$)	Observed Cost (R$)	Sinistrality	TS (70%) - S
2016	206.67	295.24	208.72	70.69%	0.69%
2017	223.44	319.21	233.13	73.03%	3.03%
2018	241.55	345.08	256.41	74.31%	4.31%
2019	274.10	391.57	258.02	65.89%	-4.11%
2020	291.65	416.64	265.63	63.76%	-6.24%
2021	288.43	412.04	305.75	74.21%	4.21%

Source: Prepared by the Authors.

The values of premiums calculated from the Credibility Theory were shown to converge to the target sinistrality in all years, presenting the TSallest difference in 2016 and the largest difference in 2020. When the average difference of the target accident rate in relation to the accident rate obtained in the period is analyzed, the value of -0.32% is obtained, indicating a sinistrality in the six-year period of 70.32%.

The method showed its greatest variation in the first year of the Covid-19 pandemic, impacted by the unpredictability of this scenario. The main advantage of applying this method to the pricing of health plans is the use of market data combined with the data of the portfolio itself, allowing the operator to adjust its premium considering the risks identified in its portfolio and in the market. As a disadvantage, there is the collection of external data, generating a dependence on the availability of this information so that it can be used.

4.4 Comparative analysis

At the end, a comparative analysis was performed between the results obtained in each of the methods used. The Table 7 provides a comparison between the claims obtained from each method, for each year.

Table 7
Comparison of Sinistrality

Year	Monte Carlo	Risk Theory	Credibility Theory
2016	65.30%	71.53%	**70.69%**
2017	**70.78%**	73.56%	73.03%
2018	74.93%	74.79%	**74.31%**
2019	73.39%	**67.89%**	65.89%
2020	72.14%	**69.09%**	63.76%
2021	77.54%	77.09%	**74.21%**
Total	72.35%	72.33%	**70.34%**

Fonte: Prepared by the Authors.

The results obtained by the Monte Carlo simulations and the Collective Risk Theory were more efficient in the year 2017 and 2020, respectively, but the Credibility Theory presented the best efficiency for the other years and, consequently, in the period as a whole, since it obtained the value closest to the stipulated goal of 70% for the accident rate.

Given the above, the results of this research corroborate the results obtained by Corrar (1998), Lemenhe et al. (2006), Macêdo, Capelo and Lopes (2018) and Paiva, Baltazar and Lumertz (2021), demonstrating that the Monte Carlo simulation is an important tool in the decision-making and strategic process in the management of health plans, since the decision maker will be aware of the range of the cost function, as well as the probability of occurrence of this information.

In addition, the results of this study regarding the efficiency of the calculation method from the Credibility Theory in the pricing of health plans corroborate the results obtained by Dias, Baltazar and Lumertz (2019), who concluded that the calculation method from the Credibility Theory proved to be adequate, because, in addition to being coherent, presents statistical and actuarial basis, allowing a satisfactory calculation of the readjustment.

5 FINAL CONSIDERATIONS

The main objective of this study was to analyze the efficiency of different methods of estimating premiums of supplementary health plans. For this, the following specific objectives were established: to compare the efficiency of the projection of care costs among the methods of pricing of health plans used, to analyze the sensitivity of each methodology to adverse scenarios and to identify the main advantages and disadvantages in the application of each method.

Based on the analyses carried out and the results obtained, it can be concluded that the Credibility Theory proved to be the most accurate method for calculating the pricing of health plans, with a total sinistrality in the period of 70.34%. This method proved to be the most efficient for the analyzed base even for the periods involving the Covid-19 pandemic.

Although the Collective Risk Theory proved to be the simplest form of calculation among the three methods approached, it was the one that presented the greatest loss of results, with a total sinistrality of 72.33% in the period. The Monte Carlo Simulation presented results very close to the Collective Risk Theory, however, for the year 2016 presented the best result among the three methods, obtaining as total sinistrality in the period the index of 71.19%.

It is important to emphasize that the results were obtained from data collected from a health plan operator in Rio Grande do Sul, from a business plan, with outpatient and hospital coverage with obstetrics, collective accommodation, with co-participation and geographical coverage being by group of municipalities. These methods can also be applied individually to other carriers, and on other bases. It is also suggested, for other studies, to perform these tests in a way segmented by age groups and the type of care cost, as defined in RDC No. 28/2000, since in the present study only the average cost per beneficiary was taken into account.

Finally, it is concluded based on the calculations performed from the three chosen methods that, in fact, one of them presents better effectiveness, demonstrating a lower accident rate than the others for most years, and also a lower average accident rate than the other three methods. Bill No. 2033/2022 makes the work of the actuary in relation to risk estimation and pricing of health plans even more complex, so identifying the pricing model with better efficiency presents a significant contribution to the academic environment, to the actuarial area and especially to the Supplementary Health market.

REFERENCES

Agência Nacional De Saúde Suplementar. (2000). *Resolução de Diretoria Colegiada - RDC Nº 28, de 26 de junho 2000*. http://www.ans.gov.br/component/legislacao/?view=legislacao&task=TextoLei&format=raw&id=Mzg3

Agência Nacional De Saúde Suplementar. (2022). *Caderno de Informação da Saúde Suplementar*. https://www.gov.br/ans/pt-br/acesso-a-informacao/perfil-do-setor/dados-e-indicadores-do-setor

Agência Nacional De Saúde Suplementar. (2022). *Tabnet Informações em Saúde Suplementar*. http://www.ans.gov.br/anstabnet/index.htm

Altieri, E. H., Melo, E. F. L., & Veiga, A. L., Filho. (2013). Modelo de cálculo da necessidade de capital para cobrir os riscos de subscrição de operações não vida. *Revista Brasileira de Risco e Seguro*, 9(17), 1-46. https://doi.org/10.17771/PUCRio.acad.37907

Araújo, Â. A. S., & Silva, J. R. S. (2018). Análise de tendência da sinistralidade e impacto na diminuição do número de operadoras de saúde suplementar no Brasil. *Ciência e Saúde Coletiva,* 23(8), 2763-2770. https://doi.org/10.1590/1413-81232018238.20572016

Brasil. (2000). *Lei N° 9.961 de 28 de Janeiro de 2000.* Brasília, DF: Presidência da República. http://www.planalto.gov.br/ccivil_03/leis/l9961.htm#:~:text=LEI%20No%209.961%20DE%2028%20DE%20JANEIRO%20DE%202000.&text=Cria%20a%20Ag%C3%AAncia%20Nacional%20de,ANS%20e%20d%C3%A1%20outras%20provid%C3%AAncia.

Brasil. (2022). *Projeto de Lei N° 2033/2022*. https://www25.senado.leg.br/web/atividade/materias/-/materia/154313

Brasil. Ministério da Saúde. (2020). Agência Nacional De Saúde Suplementar. *Resolução Normativa - RN N° 451, de 6 de março de 2020*. https://www.in.gov.br/en/web/dou/-/resolucao-normativa-rn-n-451-de-6-de-%20marco-de-2020-247535376

Brasil. Previc. (2012). *Instrução N° 03, de 10 de outubro de 2012*. https://www.gov.br/economia/pt-br/orgaos/entidades-vinculadas/autarquias/previc/regulacao/normas/instrucoes/instrucoes-previc/2012/instrucao-previc-no-3-de-10-de-outubro-de-2012.pdf/view

Bueno, L. P. (2017). *Métodos estatísticos básicos para seguros em gerais* (1 ed.) Rio de Janeiro: ENS-CPES.

Cata Preta, H. (2004). *Gerenciamento de operadoras de planos privados de assistência à saúde: atendimento aos usuários, controle dos custos operacionais e efetividade e qualidade dos serviços* (1 ed.). Rio de Janeiro: Funenseg.

Cella, J. L. D. J. (2019). *Efeitos da crise econômica de 2014-2016 sobre o mercado brasileiro de saúde suplementar*. (Dissertação de Mestrado). Universidade Presbiteriana Mackenzie, São Paulo.

Chan, B. L. (2010). *Risco de subscrição frente às regras de solvência do mercado segurador brasileiro*. (Tese de Doutorado). Universidade de São Paulo, São Paulo. https://teses.usp.br/teses/disponiveis/12/12136/tde-17122010-094901/pt-br.php

Corrar, L. J. (1998). Projeção de custos e o método de simulação de Monte Carlo: O caso da fundação Salute. *Anais do Congresso Brasileiro de Gestão Estratégica de Custos, Fortaleza*, Fortaleza, Brasil, 5. https://anaiscbc.emnuvens.com.br/anais/article/view/3276

Dias, M. M. O., Baltazar, L., & Lumertz, J. A. (2021). Método de cálculo de reajuste por variação de custos para contratos de planos de saúde suplementar a partir da teoria da credibilidade. *Revista Eletrônica do Departamento de Ciências Contábeis e Departamento de Atuária e Métodos Quantitativos da FEA*, 8(2), 87-110.

Dourado, E. S. (2020). *Precificação de Planos de Saúde Suplementar* (Trabalho de conclusão de curso de Pós-Graduação). Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Ferreira, P. P. (2010). *Modelos de precificação e ruína para seguros de curto prazo*. Rio de Janeiro: Funenseg.

Figueiredo, B. L. S. (2021). *Análise da saúde pública brasileira: o sistema único de saúde (SUS), suas fontes de financiamento, desafios e a presença do terceiro setor* (Trabalho de Conclusão de Curso). Escola de Direito e Administração Pública do Instituto Brasiliense de Direito Público EDAP/IDP, Brasília.

Gerhardt, T., & Silveira, D. (2009). *Métodos De Pesquisa* (1 ed.). Porto Alegre: Editora da UFRGS.

Gil, A. C. (2018). *Como elaborar projetos de pesquisa* (6a ed). São Paulo: Atlas.

Hammersley, J., & Handscomb, D. (1964). *Monte Carlo methods*. London: Methuen.

Lemenhe, F. et al. (2006) O método de Simulação de Monte Carlo para precificação de planos de saúde: uma abordagem didática. *Anais do Encontro Nacional de Engenharia de Produção*, Fortaleza, Brasil, 26. http://www.abepro.org.br/biblioteca/enegep2006_tr460316_8382.pdf

Macêdo, D., Capelo, E., Júnior, & Lopes, E., Júnior. (2018). Determinação do preço assistencial em planos de saúde utilizando simulação. *Sistemas e Gestão*, 13(1), 81-87.

Malehi, A. S., Pourmotahari, F., & Angali, K. A. (2015). Statistical models for the analysis of skewed healthcare cost data: a simulation study. *Health Economics Review*, 5(11), 1-16.

Marconi, M., & Lakatos, E. (2019). *Fundamentos de metodologia científica* (8 ed). São Paulo: Atlas.

Mendes, P. C. (2015). A eficiência, eficácia, efetividade e economicidade dos batalhões de engenharia de construção e seus destacamentos. *Syria Studies*, 7(1), 37-72.

Organização Pan-Americana Da Saúde, Agência Nacional de Saúde Suplementar, & Ministério da Saúde. (2021). *Risco de subscrição no mercado de saúde suplementar brasileiro: uma nova regulamentação*. Brasília. https://iris.HCPP.org/handle/10665.2/53832

Paim, J. S. (2018). Thirty years of the unified health system (SUS). *Ciência e Saúde Coletiva*, 23(6), 1723-1728. https://doi.org/10.1590/1413-81232018236.09172018

Sá, M., Maciel, J., Júnior, & Reinaldo, L. (2017). Processo de Ruína Finito: um Estudo de Caso na Saúde Suplementar no Brasil. *Revista Evidenciação Contábil e Finanças*, 5(2), 88-103.

Salgado, P. (2018). *Judicialização da saúde suplementar no Brasil* (Trabalho de conclusão de curso). Universidade Federal Fluminense, Niterói, Brasil.

Saraiva, A. F., Júnior, Tabosa, C. M., & Costa, R. P. (2011). Monte Carlo simulation applied to order economic analysis. *Produção*, 21(1), 149-164. https://doi.org/10.1590/S0103-65132011005000016

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