# Estimation of health insurance shocks on the health of Colombians

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# 1 Introduction

The healthcare system in Colombia connects patients, insurers, and healthcare providers. All the institutions that are part of this system are interconnected, making it difficult to avoid the repercussions that a crisis in one institution can have on the others. Actually, this entire system is going through a structural crisis, one of the causes of this financial stress is the liquidity restrictions of the health insurance companies. When a Health Promoting Entity (EPS) goes bankrupt, the affiliates go through a process of a random redistribution among the other EPS, this can affect the Health Provider Institutions (IPS) because the absence of payments from a certain EPS to the IPS may affect its capacity to provide services. In this exercise, we want to estimate the effects of such bankruptcies on health utilization in Colombia.

Health utilization will be used in this case to measure the impact of EPS bankruptcies on the overall health care system. For this purpose, the difference-in-differences and event study methods are used as techniques that measure the effect of a treatment in a certain period of time, in order to compare the health utilization of an IPS before the EPS bankruptcy and after to see how it affects the health system in general.

The connection between health utilization and health quality is seen in different ways in the literature, on the one hand, (Skinner, 2011) finds that the increase in health utilization has increased health indicators and decreased the mortality rate, however (Finkelstein *et al.*, 2012) found that there is no correlation between health utilization and the health of the people who use the system. This project seeks to understand the basic estimation econometrics models and then learn about the most robust models and the most recent literature, using this to analyze the causal effects that these bankruptcies have on the health system in general and more specifically on health utilization. Through the study on the impact on health utilization, we can understand what is the effect on the health of all the people who are transferred from one EPS to another or of the people who frequent the IPS affected by these crises.

# 2 Statement of the problem

## 2.1 Statement of the problem

The health system in Colombia was created by Law 100 of 1993 with the objective of favoring insurance as the main instrument to achieve the highest possible coverage, especially among the poorest population (María *et al.*, 2007). The General Social Security Health System (SGSSS) is made up of: the State through the Ministry of Health and Social Protection, which acts as the coordinating, management and control agency; the Health Promoting Entities (EPS), responsible for affiliation, collection of contributions and guaranteeing the provision of the Mandatory Health Plan to affiliates; and the health provider institutions (IPS), which are the hospitals, clinics and laboratories, in charge of providing services to users. The Territorial Entities and the National Health Superintendence are also part of the General Social Security System, as control and surveillance entities (MINSALUD, 2022). The system has two types of affiliation regimes, the contributory and the subsidized. The contributory regime (CR) is made up of workers who contribute a portion of their salary to have health coverage for themselves and their families. These individuals have a package of benefits such as treatments and drugs covered, known as the Mandatory Health Plan (POS). The subsidized regime (RS) includes the poorest, most vulnerable population with no ability to pay. Individuals classified in levels 1 and 2 of the SISBEN are considered poor. These individuals

receive free of charge, health insurance that covers a proportion and variety of events that is lower than that of the CR. This plan is known as the Subsidized POS (POS-S) (María *et al.*, 2007).

The system is financed with three main sources: the first is the contributions made by contributors to the RC; the second is general taxes, and the third is the territorial income and the own resources of departments and municipalities (María *et al.*, 2007). The first of these sources corresponds to a payroll contribution of 12.5% of the worker's contribution base income (IBC), of which, in the case of a dependent worker, the employer will contribute 8.5% and to the employee 4% (Actualicese.com, 2022). The second source is a contribution of one point five (1.5) for individuals who earn more than one minimum wage, which is transferred to the ADRES Solidarity subaccount to contribute to the financing of the beneficiaries of the subsidized regime (Congreso de la República de Colombia, 2007). ADRES is also financed with resources provided by the General Budget of the Nation (PGN), either as "pari-passu" or as autonomous contributions from the National Government. This constitutes the source of general taxes, the second source mentioned. Most of the resources from this source are transferred to the regions through the General Participation System (SGP). Law 715 of 2001 establishes that 24.5% of the SGP must be used in health, financing the three main uses that are SR, attention to affiliates, and public health. The third source originates mainly from the income transferred to municipalities and departments that come from taxes on games of chance, liquor, and cigarettes, and the fiscal efforts of the municipalities and departments (María *et al.*, 2007). It is important to mention that FOSYGA acts as an entity that adjusts the system. In other words, given that each RC contributor contributes a different amount to finance their insurance (depending on the amount of their salary), FOSYGA collects all the contributions and compensates the EPS and ARS for beneficiaries with different salaries and risk profiles. This is carried out in the FOSYGA "Compensation Account" and the EPS and ARS receive a Capitation Payment Unit (UPC) for each affiliate (María *et al.*, 2007).

The subsidized health system is one of the programs with the greatest social impact in recent years in Colombia, with positive results in terms of its policy objectives inequity of access and financial protection for beneficiaries (Beltran, 2016). However, this regime presents inefficiencies in its results, such as the reduction in profit margins and the concentration of risks. In addition, the substantial expansion in coverage has also been accompanied by a growing demand for quality by the population, and the elevation of health to a fundamental right has translated into effective coverage. Added to the foregoing are the well-known cases of corruption in the sector (de Transparencia, 2021), which have created enormous pressure on the resources that finance patient care, reflected in liquidity problems for insurers, less funding for hospitals and clinics, and the impact on the services provided to patients. Health insurers (EPS) are highly regulated by the Colombian State through the Ministry of Health and Social Protection (MSPS) and the National Health Superintendence. To deal with the financial problems, the regulatory authorities have created requirements on the equity and liquidity of the EPS, however, this has not been enough to prevent many insurers from going bankrupt, as well as health providers (Montenegro, 2018). These economic breakdowns have a big impact on the sustainability of the Colombian health system due to the interdependent relationship that exists between EPS, IPS, and other actors in the health sector, since the transfer of affiliates is necessary, the financial stability of the other health care providers could be under risk.

The distribution of EPS users that enter bankruptcy proceedings has an effect on other health entities. If these impacts are not mitigated in time, they can have major consequences on the financial stability of the other entities belonging to the health system, whether it is a short-term or long-term effect. During the years 2003 and 2019 there were 10 events of bankruptcies in health, this leads us to think if reform in the structure of the Colombian health system is necessary. For this

reason, it is important to analyze the impact that a bankruptcy process has on the use of health, taking into account that this is an event that is not anticipated in advance and that the measures to carry out the transfer must be taken quickly, it is necessary to estimate the effects that these bankruptcies have on the other systems and thus analyze the impact it has on the health of the people who were affiliated with it.

To capture the causal effects of bankruptcies, the difference-in-differences (DID) econometric method is used, which is a quasi-experimental design that makes use of longitudinal data from the treatment and control groups, that is, a group that makes an intervention and the control group in which there is no intervention, to obtain an appropriate counterfactual to estimate a causal effect. This method is used to estimate the possible effects of an unexpected event to understand the causal connection between the bankruptcy of the EPS and the health of transferred members.

To date, qualitative research has been carried out with legal methodologies on the effects of changes in health in Colombia, as in María *et al.* (2007), where they question whether the regulatory changes in the operating conditions of the subsidized regime are a determinant of the structure of the insurance market, for this, they use a panel data analysis of fixed effects for the period 1999 to 2013. However, the investigations carried out are only based on normative, jurisprudential, and doctrinal components. Other investigations have analyzed the different agents that intervene in isolation and, as stated in Montenegro (2018), the interrelationship that exists between the different institutions must be taken into account. In this research, they raise the existing relationships between insurers, service providers, and other actors, which lead to interdependence, giving rise to a domino effect on the financial situation of these companies. They also seek to study the systemic risk present in the Colombian Health System based on a network analysis methodology.

In Badillo & Villa (2021) they assess the effect of shocks to health insurance companies on hospital finances and patient health. For this purpose, they use granular data on the medical services offered in Colombia between 2009 and 2019. They use the variation between the relationships of insurers and hospitals to decompose their specific fixed effects into idiosyncratic shocks. Analyzing the effect of these shocks on the finances of hospitals and the health of patients, they find that the positive impact of spending on health increases the liability-asset ratio of hospitals by 8.7% and by 1.2% the liability-equity relationship. Finally, they show that an increase of one standard deviation in the shock of using health services caused by insurance companies generates a 7% increase in the probability of death from ischemic heart disease.

This work differs from the approach Badillo & Villa (2021) in the sense that here specific events of bankruptcy processes of insurers are used to identify causal relationships, while Badillo & Villa (2021) they add all the potential health shocks that occur, either in IPS or EPS, on people's health. In this exercise, the implementation of DID is fundamental, since it plays an important role in the absence of treatment, the differences not observed between the treatment and control groups are the same over time. This is a useful technique to use when randomization at the individual level is not possible. The approach removes biases in post-intervention comparisons between treatment and control groups that could be the result of permanent differences between those groups.

This project aims to estimate the effects of insurance company bankruptcy processes on Colombian health use by comparing different econometric methods.

## 2.2 Formalization of the problem

The Differences-in-Differences (DID) method is a quasi-experimental design that makes use of longitudinal data from treatment and control groups to obtain an appropriate counterfactual for

estimating a causal effect by comparing changes in outcomes over time between a population that is treated (treatment group) and a population that is not treated (the control group).

In DID, the data is divided into two groups, control group (0) and the treated group (1). Also its important to observe the outcomes in the two groups over the two periods. The method to estimate the effect of the treatment.(Friosavila, n.d.)

Here we can observe how much the outcome of an individual has increased before and after the treatment:

$$D1 : y(1)i1 - y(1)i0 = \tau_i + \theta_i \tag{1}$$

Looking at how the outcome has changed from one period to the other captures not only the effect we are after $\theta_i$, but also natural growth, we were expecting $\tau_i$. Only if you have strong assumptions of $\tau_i = 0$ would this approach be appropriate. This second alternative compare outcomes for the treated and untreated groups, and identify the effect as that difference:

$$D2 : y(1)i1 - y(0)j1 = u_i - \tau_i + \theta_i - (u_j + \tau_j) \tag{2}$$

$$D2 : y(1)i1 - y(0)j1 = (u_i - u_j) + (\tau_i - \tau_j) - \theta_i \tag{3}$$

This approach is also incorrect. First of all, it requires the assumption that $\tau_i = \tau_j$.It also requires the assumption the potential outcomes of both individuals before treatment were the same ( $u_i = u_j$).

The Difference-in Difference design suggests instead using a double difference. Capturing the benefits of the first and second approach:

$$DD : [y(1)i1 - y(1)i0] - [y(0)j1 - y(0)j0] \tag{4}$$

$$DD : [y(1)i1 - y(0)j1] - [y(1)i0 - y(0)j0] \tag{5}$$

Which gives:

$$DD : TE_i = \theta_i + (\tau_i - \tau_j) \tag{6}$$

# 3 Objectives

## 3.1 General objective

To estimate the effects of insurer bankruptcy processes on the use of health by Colombians, by comparing different econometric methods.

## 3.2 Specific objectives

- To review the use of econometric models such as the differences-in-differences method for estimating causal effects in the health area.
- To review the most recent methods implemented in recent years for the estimation of causal effects in the health area, and to identify controversies generated by said methods.
- To implement different relevant methods to estimate the effects generated by economic bankruptcies on the use of health by Colombians.

- To analyze and to interpret the results of each implemented method.
- To compare the results of the different methods and define the best one for estimating the effects of bankruptcies on the use of health by Colombians.

# 4 Justification

The purpose of the project is to estimate the effects of insurer bankruptcy processes on the use of health by Colombians, by comparing econometric methods. This problem arises from the negative effects of the redistribution of EPS users who enter bankruptcy proceedings, since they have great consequences on the financial stability of the other entities belonging to the health system, both in the short and long term. With the redistribution of affiliates, the risk inherent in meeting their health needs is transferred. Therefore, if the composition of the affiliated portfolio of a receiving EPS fails to effectively distribute the risk of new users a situation can be created in which the initial failure of an insurer leads to situations of financial stress for the companies. Entities that receive members of the first (Montenegro, 2018). This situation demonstrates the need for reforms in the structure of the Colombian health system.

This proposal is linked to the research of Christian Posso and Leonardo Bonilla, researchers from the Banco de la República de Colombia. This link is important given the complexity of the Colombian health system and its financing system, taking into account that these events of the breakdown of the EPS are not foreseen and that the measures to carry out the transfer must be taken quickly when dealing with the health of a large number of people, it is necessary to estimate the effects that these bankruptcies have on the other systems involved and thus analyze what impact they have on the health use of affiliated people. Therefore, the use of econometric methods such as differences-in-differences is pertinent to estimate the effects of insurer failures on health utilization by Colombians. Allowing the incorporation of variables such as the insurers affected and those that are not affected by the breakdowns, the people affected and those who are not and each of the medical services offered by the insurers affected by the event. Furthermore, this type of econometric method allows an intuitive interpretation of causal effects from observational data letting us to use any of the individual and group level data, this is useful for performing different explorations at different levels of aggregation; it also allows comparison groups to start at different levels of the outcome, and the incorporation of different factors in the intervention or event under study.

This work will allow the entire society to be informed about the effects of EPS bankruptcies, this information is really important for the creation of new policies and regulations that help avoid or mitigate these unfortunate events. This information will be a valuable contribution to the Ministry of Health, as it will be a new source of information and a tool for decision-making in the country. This research aims to offer a broader overview of the EPS bankruptcy processes in Colombia.

In addition, this research practice is aligned with the domain areas of Mathematical Engineering: modeling, data analysis, computing, and integration with other areas of knowledge such as econometrics with causal models for estimation and prediction. Using data analysis to analyze all the information necessary for the estimates, as well as the relevant results according to the purpose of the study and modeling to represent different behaviors of the variables under study. For this, different compilation tools will be used and algorithms will be built efficiently and rigorously. Through the econometric models for the estimation, we will contribute to understand the effects of the breaks of the EPS in Colombia. In addition, this model could be adapted to other types of problems and environments and even to other areas of knowledge. Data analysis is essential due to the

large amount of information that is generated in the healthcare sector, so it's relevant the use of statistical tools. On the computational side, the implementation of the model must be adequate. It must include a large population with different variables so computational efficiency and ease of use must be present.

Finally, integration with other areas of knowledge such as economics is very important. Being able to work with people from different areas and put the knowledge learned in the course into context generates added value and a high degree of satisfaction as students.

# 5 Scope

This research project will lead to the comparison of different econometric methods for the estimation of the effects of insurance bankruptcy processes on the health utilization of Colombians. This will include graphical results of the health utilization of Colombians before and after the bankruptcy event. This utilization is calculated as the product of the amount of health services used by their standard prices established by the Ministry of Health. The variables to be included are all persons who have used the health services of the EPS´s to be evaluated in the period under study; the standard prices of these health services, which are prices regulated by the Colombian Ministry of Health; and time, i.e., before and after the event under study.

The expected results are:

- A report with literature review of econometric methods for estimating causal effects in health care.
- A report with the most recent literature review identifying the controversies generated by these methods.
- Implementation of the most relevant methods in the literature for the estimation of the effect of insurers' shocks on the health utilization of Colombians, with their respective analyses.
- A report with the comparison of the studied methods applied to the data.

# 6 State of the art

Due to the poor financial and administrative management of the EPS in Colombia, the health system has gone through some crisis in which all the actors that are part of this system are involved, proving that it is necessary to identify the shortcomings and adopt measures to avoid a major crisis that could affect the entire health system (Triviño, 2013). For this reason Montenegro (2018) talks about the importance of not isolating the liquidity crises of the insurers from the rest of the actors that are part of the health sector, considering the interdependence that exists between the whole system. To study the repercussions of the EPS bankruptcy processes Montenegro (2018) analyzes the systemic risk, that is, the possibility that the bankruptcy of an EPS may lead to the failure of the other institutions taking into account the interconnection between all these systems, all this by means of graph analysis. From this methodology implemented, the results showed the type of implications on the Contributive Regime of the Health System at the moment of distributing affiliates from one EPS to others after its bankruptcy process, demonstrating the need to consider specific aspects of the reassigned affiliates and to consider the financial situation of the EPS that receive new users in order to avoid the failure of the other institutions.

Using the econometric technique of difference-in-differences, it´s possible to estimate the possible effect of the bankruptcy process on health utilization. Different authors have implemented this technique for research that seeks to evaluate the impact of an event or treatment in a specific period, such as Gertler & Boyce (2001) who apply the difference-in-differences method to measure the impact of the PROGRESA program, which promotes welfare based on incentives, motivating families to invest in education, health, and nutrition. The results of this research showed that people living in the areas intervened by PROGRESA began to frequent more public clinics, increasing visits by 66%, which shows the effectiveness of the program in raising awareness about the importance of health care. On the other hand, Kim *et al.* (2018) aimed to assess the impact of visual impairment on the use of health services, for this, health care expenditures were compared between prior and subsequent visual impairment for visually impaired persons using the DID method, the output of this exercise shows that visually impaired persons spent 5.7% and 6.8% more in total health care expenditures per month and outpatient health care expenditures, respectively than non-visually impaired persons, after adjusting for differences before the disability.

The difference-in-differences (DD) method has its origins in the field of econometrics however John Snow introduced for the first time the logic of this technique by demonstrating that cholera is transmitted by infected water and not through the air, this technique is called "Controlled before-and-after study" Snow (1885), an estimate through DD is the difference between the change in the results before and after treatment in the treatment group versus the difference between the change in the results before and after the control group. Ashenferter (1978) introduced the estimation method in the field of economics by estimating the impact of training programs on the income of people who had participated in them. Later David Card contributed to econometrics with different studies, in particular, the classic problem of the minimum wage increase Card & Krueger (1994) in which New Jersey increased the minimum wage from $4.25 to $5.05 and Pennsylvania maintained its rate at $4.25, as a result of the application the method showed how the increase in the minimum wage in New Jersey increased employment, the employment rates of young people increased, the prices of fast food increased indicating that the minimum wage was reflected in the prices charged to the consumer.

In the last years, the interest in the analysis of causal relationships has caused great advances in the literature about the difference-in-differences method leading to a great variety of information about the different components of DiD, this makes it difficult to understand how all these extensions of the method fit together that's why Roth *et al.* (2022) synthesize the most recent publications. One extension of DiD is the doubly robust method of H.C. *et al.* (2020) in which they study the robustness and efficiency of DiD estimators for ATT (average treatment effect on the treated) when the PTA (parallel trends assumption) holds after conditioning on the covariates. On the other hand, Callaway & Sant'Anna (2020) explored the dynamic event study methods, they consider the estimation and inference of the treatment effect using DiD with multiple time periods, there is a variation in the time of the treatment when the PTA is maintained only after conditioning the observed covariates. To give continuation to the dynamic event study models following the advances of the last-mentioned authors Rambachan & Roth (2020) propose robust DiD estimation methods in which the events do not require the parallel trend assumption to hold.

# 7 Proposed methodology

In this research practice, a review of the literature will be developed to know and identify the different mathematical and econometric methods implemented for the estimation of the causal effects in the health area, particularly the financial bankruptcy processes of Colombian insurers that affect use in public health. This research integrates two areas of knowledge that are mathematical modeling and econometrics. Initially, a literature review of both the basic methods and the new methods used in recent years will be carried out, to identify the controversies and the key components of each methodology. For the implementation of the most relevant methods, an iterative process will be considered that involves the structuring of the problem, modeling, and implementation (Pidd, 2009). First, the definition of requirements, variables, and assumptions, the use of regression models for the interaction between time and other variables; finally making the estimates.

The main method to implement is differences-in-differences. This method is used to estimate the effect of a specific intervention or treatment by comparing changes in outcomes over time between a population that is intervened with an event (the intervention group) and a population that is not (the control group) (Cunningham, 2021). DID is used in cases where interchangeability between treatment and control groups cannot be assumed. DID is based on a less stringent interchangeability assumption, that is, in the absence of treatment, the unobserved differences between treatment and control groups are the same over time. Therefore, this is a useful technique to use when randomization at the individual level is not possible. DID requires data from before and after the intervention, such as cohort or panel data (individual level data over time) or repeated cross-sectional data (individual or group level). The approach removes biases in post-intervention comparisons between treatment and control groups that could be the result of permanent differences between those groups (Columbia Public Health, 2022).

To estimate any causal effect, the following assumptions must be met: interchangeability, positivity, and stable unit treatment value assumption. In addition, it requires that the intervention not be related to the outcome at baseline (intervention allocation was not determined by outcome); treatment and control groups have parallel trends in outcomes (in the absence of treatment, the difference between "treatment" and "control" groups is constant over time); the composition of the treatment and control groups is stable for the repeated cross-sectional design; and the absence of indirect effects Columbia Public Health (2022).

The advantages of the differences-in-differences method are: it allows for intuitive interpretation, it allows a causal effect to be obtained using observational data if assumptions are met, individual and group-level data can be used, comparison groups can start at different levels of the result. (DID focuses on change rather than absolute levels), plus accounts for change due to factors other than the intervention. However, the method also has some limitations, such as it requires baseline data and a no-intervention group, the method cannot be used if intervention allocation is determined by baseline outcome, it cannot be used if intervention groups comparison has a different result trend, it cannot be used in the composition of the groups before/after the change is not stable Columbia Public Health (2022).

# 8 Schedule

Table 1: Schedule

| *Activity* | *Weeks* | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* |
| Activity 1: Basic literature review | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| Activity 2: New literature review | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| Activity 3: Implementation | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Activity 4: Analysis of results | | | | | | | | | | | | | | | ■ | ■ | ■ |

# 9 Intellectual property

According to the internal regulation on intellectual property within Universidad EAFIT, the results of this research practice are product of *Manuela Guarnizo Sepulveda*, *Verónica Mendoza Iguarán*, *Christian Manuel Posso Suárez* and *Leonardo Bonilla Mejía*.

In case further products, beside academic articles, that could be generated from this work, the intellectual property distribution related to them will be directed under the current regulation of this matter determined by Universidad EAFIT (2017).

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