UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

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Avaliação de Impacto da Campanha Nacional de Vacinação da Gripe

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Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Economia da Indústria e Tecnologia, Instituto de Economia, Universidade Federal do Rio de Janeiro, como requisito parcial à obtenção do título de Mestre em Economia

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Avaliação de Impacto da Campanha Nacional de Vacinação contra Influenza nos Idosos

Dissertação de Mestrado apresentada ao Instituto de Economia da Universidade Federal do Rio de Janeiro para obtenção do título de Mestre em Ciência Econômica

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Avaliação de Impacto da Campanha Nacional de Vacinação da Gripe

RESUMO

Esta Dissertação examina o efeito do Programa Nacional de Vacinação contra a Influenza sobre taxas de hospitalização e taxas de mortalidade por doenças respiratórias na população idosa. Nossa estratégia empírica explora mudanças no público-alvo da campanha ao longo do tempo. Achamos que a campanha de vacinação contribui para diminuir as taxas de internação de doenas respiratórias em idosos. O efeito é maior nas regiões Sul e Sudeste, e nas estações de Inverno e Primavera. Encontramos heterogeneidades no efeito da campanha de acordo com as características demográficas das micro-regiões, e seu acesso ao sistema de saúde pública. Achamos que a campanha da vacina contra a gripe contribui para diminuir as taxas de mortalidade por doenças respiratórias nas regiões Sul e Sudeste.

JEL Codes: I12, I18, D62, H23

Palavras chave: Vacina, Vacinação, Influenza, Economia da Saúde

ABSTRACT

This paper examines the effect of the Brazilian National Influenza Immunization Program on hospitalization and mortality rates from respiratory diseases in the elderly population. Our empirical strategy exploits changes in the targeted audience of the campaign over time. We find that the Influenza vaccine campaign contributes to decreasing the hospitalization rates from respiratory diseases in elderly. The effect is larger in the South and Southeast regions, and in the Winter and Spring seasons. We find heterogeneities in the effect of the campaign according to demographic characteristics of micro regions and their access to the public health system. We find that the Influenza vaccine campaign contributes to decreasing the mortality rates from respiratory diseases for South and Southeast regions.

JEL Codes: I12, I18, D62, H23

Keywords: Vaccine, Vaccination, Influenza, Flu, Health Economics

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1 Introduction

The seasonal Influenza is a serious public health problem that causes illness and death in high risk populations (WHO, 2016). Every year the Influenza virus causes between 250,000 and 500,000 deaths in the world (Palache et al., 2015). In Brazil, hospitalizations from respiratory diseases represent the second most frequent cause of hospitalization among the elderly (Daufenbach et al., 2009). The main policy to control the Influenza virus is vaccination. In 2000, 78% of developed or developing countries recommended vaccination for elderly people (Jefferson et al., 2005). According to Donalisio et al. (2007), Brazil is the country with the highest investment in Influenza vaccination campaign. In Brazil almost 50 million people are vaccinated per year (SI-PNI, 2016). However, the effectiveness of this policy is still uncertain (Jefferson et al., 2005). Systematic reviews of the effects of the Influenza vaccine find inconclusive results of the vaccination on respiratory diseases (Demicheli et al., 2007; Demicheli et al., 2014; Luna and Gatts, 2010).

In this paper, we examine the effect of the Brazilian National Influenza Immunization Program on hospitalization and mortality rates from respiratory diseases among the elderly. The Brazilian National Influenza Immunization Program was introduced in 1999 only for individuals over 65 years old and health system officials. In 2000, the Brazilian Ministry of Health extended the target audience of the campaign to incorporate the elderly between 60 and 64 years old. The vaccination rates are high, exceeding the minimum (70%) recommended by WHO (2012). We exploit changes in the eligible target audience to receive the Influenza vaccine. The Brazilian National Influenza Immunization Program occurs all over Brazil at same time, always in late autumn. So we also explore regional and seasonal differences to capture heterogeneity in effects of Influenza campaign vaccination. Finally, we examine how some mechanisms can influence the effect of the Influenza vaccination campaign.

We use a difference-in-differences strategy to compare the rates of hospitalization and mortality between groups eligible versus not eligible to receiving the Influenza vaccine. We construct a panel of hospitalization and mortality rates per year, by age, micro-regions of residence, and type of diseases. Our sample contains data from 558 micro-regions in the period from 1996 to 2004, for individuals aged 55 years old up 74. The identification of the causal effect of vaccination is based on the hypothesis that conditional on fixed effects of micro-regions, age group and time, controls for health infrastructure and specific trends of micro-region and states, the variable of vaccination is orthogonal to any other determinants of hospitalization or mortality by respiratory diseases.

The second stage of this paper focuses on exploring the heterogeneities on the vaccination campaign effects across macro-regions and seasons. We also interact the effect of the Influenza vaccine with political and demographic variables that affect the environment in which the vaccine was applied. Finally, we perform robustness and placebo tests to assess the validity of the results.

Our findings indicate that vaccination reduces hospitalization from respiratory diseases. We find that the Influenza vaccination campaign reduces hospitalization rates per 1000 inhabitants in 6%. The effect is larger in the South and Southeast regions, and in the winter and spring seasons. We interact our effect according to political and demographic variables. We find heterogeneities in the effect of the campaign according to demographic characteristics of micro regions and their access to the public health systems. In particular, we find that the effect of the campaign on hospitalization rates is larger where the population density is higher, where there are more people living in slums, and where the penetration of other health programs is also higher. We find effect of the vaccination on mortality rates from respiratory diseases for South and Southeast regions.

A meta-analysis grouping the studies on the impact of the vaccination campaign coverage on hospitalization rates for Influenza finds a correlation of 0.09 between the proportion of people vaccinated and the proportion of people infected by the Influenza virus (Jefferson et al., 2005). Some studies use randomization to identify the effect of the Influenza vaccine, but the results are inconclusive and face the problem of external validity (Victor et al., 2016; Brooks et al., 2016) . These results indicate the importance of analyzing the environment in which the vaccine was applied to capture mechanisms that may amplify or mitigate the effect of the campaign. In Brazil, most studies on Influenza vaccination use time-series methods to analyze trends, but fail to identify the causal effect of vaccination policy(Demicheli et al., 2007). Ward (2014) explores the vaccine quality in Canada, she finds that the vaccine contributes to decreasing lost work-time, hospitalization, and death. We find robust evidence that the Brazilian National Influenza Immunization Program led to a decrease of both hospitalization and mortality by respiratory diseases. Brazil is a country with great geographical and demographic differences between macro-regions. Therefore, we also contribute to the literature by analyzing the environment in which the vaccine was applied, finding heterogeneous effects of the vaccine across regions and seasons. Finally, we contribute by analyzing political and demographic mechanisms that alter the effect of the Influenza vaccine

The remainder of the paper is structured as follows. Section 2 describes the Institutional Background, while section 3 presents the data on hospitalization and mortality in Brazil. Section 4 describes the empirical strategy. Section 5 presents the main econometric results, discusses mechanisms, and performs robustness exercises. Section 6 closes the paper with some concluding remarks.

2 Institutional Background

2.1 Seasonal Influenza

The Influenza is an acute viral infection that spreads easily from person to person. The Influenza virus affects the respiratory system and causes illness and death in high risk populations. Worldwide, the seasonal Influenza is a serious public health problem that results in about 3 to 5 million cases of severe illness, and about 250 000 to 500 000 deaths per year (WHO, 2016). Transmission occurs through contact with secretions of the respiratory tract of the infected person. Plans-Rubió (2012) estimates that an infected person is able to transmit the virus to up to two non immune people. In temperate climate zones, seasonal epidemics occur mainly during the winter, while in tropical regions, Influenza seasonality is less obvious and epidemics can occur throughout the year.

The World Health Organization recommends vaccination for the Influenza virus as main strategy to prevention and control of the virus. According to the WHO (2016), vaccination can reduce the risk for Influenza-related complications and block the transmission of Influenza viruses in the community by establishing herd immunity. The WHO (2016) indicates the elderly as the priority population for the vaccine, because in non-vaccinated populations the majority of deaths are in the elderly. In 2000, 40 of 51 developed or rapidly developing countries recommended vaccination for all individuals aged 6065 or older, and, in 2003, 290 million doses of vaccine were distributed worldwide (Van Essen et al., 2003). The Influenza virus is rapidly mutating, so the WHO recommends annual frequency of vaccination. Annually, the WHO indicates which viral strains should be included in the next seasons vaccinations.

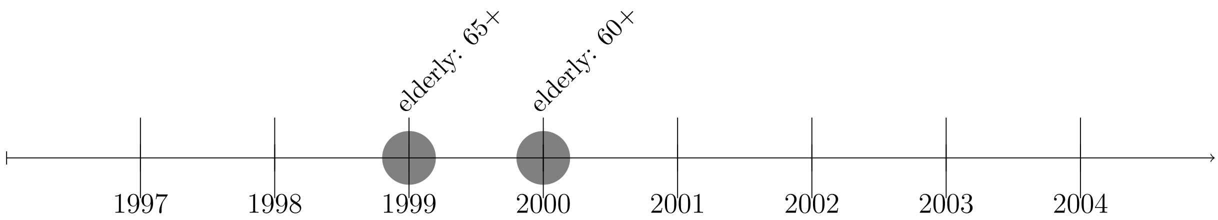
2.2 The Brazilian Influenza Vaccination Campaign

The Brazilian Influenza Vaccination Campaign was incorporated into the Brazilian Immunization Program (PNI) in 1999. It is an ongoing project of the Unified System of Health (Sistema nico de Sade), from the Brazilian Ministry of Health. The aim of the campaign is at reducing hospitalizations, complications, and deaths from respiratory diseases in the target population of vaccination. According to Donalisio et al. (2007), Brazil is the country with the highest investment and coverage for Influenza vaccination of the elderly, surpasses the 70% target set by the Ministry of Health. Almost 50 million people are vaccinated per year (SI-PNI, 2016). Since 1999, there has been a continuous expansion of the program.

The Brazilian Influenza Vaccination Campaign is a federal program that is implemented at the municipality level. The campaign involves the federal, state, and municipal governments. The campaign is financed by the Federal Government, the State Secretaries of Health (SES) and the Municipal Health Secretariats (SMS). According to (SI-PNI, 2016), it involves around 65,000 vaccination posts, 240,000 people and use of 27,000 vehicles (land, sea and river) per year. In 2017, the vaccination campaign acquired 60 million vaccines. Each vaccine costs RS 14.50, so the total cost of the campaign is RS 864.6 million. Each person takes only one dose.

The vaccination campaign has an annual frequency due to rapid mutation of Influenza virus. Every year, the WHO recommends what the content of the vaccine should be, based on most prevalent viral strains circulating that year. The WHO recommends the vaccine to be applied just before the winter, the period with the greatest number of cases of Influenza. The vaccine takes up to two weeks to begin effect. So the campaign in Brazil happens just before the winter, between the second fortnight of April and the first fortnight of May. The campaign takes place at the same time for all municipalities. Annually, vaccination coverage has exceeded the 70% of the target public. Thus, the Brazilian Influenza Vaccination Campaign is characterized by high coverage rates.

The vaccination campaign has introduced changes to the target group over time. The campaign started in 1999 with only the elderly over 65 as a target group. In 2000, the Brazilian Ministry of Health extended the campaign to incorporate the elderly between 60 and 64 years old. Figures 1 and 2 illustrate the changes in the target group of the campaign over time.



Although the initial focus is the age groups, nowadays other groups also participate in the campaign. In 2017, the Brazilian Influenza Vaccination Campaign vaccinated pregnant woman, postnatal woman, health workers, Brazilian Indians, prisoners, workers in the penitentiary system, teachers and the chronically ill.

2.3 The Impact of the Influenza Vaccine

Although Influenza vaccination is recommended worldwide, the literature finds Influenza vaccine campaigns to have a very modest effect in reducing Influenza symptoms (Demicheli et al., 2014). Jefferson et al. (2005), grouping 64 studies on the impact of the vaccination campaign coverage on morbidity rates for Influenza, find a most correlation of 0.09 between the percentage of population covered by Influenza vaccination and infection by Influenza. Ward (2014) explores exogenous variation in vaccine quality in Canada, she finds that the vaccine contributes to decreasing lost work-time, hospitalization, and death. Brooks et al. (2016) used randomised, double-blind, placebo-controlled trial for a sample in Bangladesh and conclude that the Influenza vaccine is efficacious at preventing symptomatic Influenza illnesses.Victor et al. (2016) used the same vaccine and empirical strategy for a sample in Senegal and concluded that the Influenza vaccine does not provide protection against Influenza. This difference in results reveals the problem with external validity.

The literature that assesses the impact of Influenza in Brazil follows the international literature and also points out to very modest results of the vaccination campaign (Luna et al., 2014). Daufenbach et al. (2009) and Campagna et al. (2009) use time series to analyse trends in hospitalization rates and mortality after the campaign. They find that hospitalization trends dropped a little after the campaign, but nothing happens with mortality trends. The authors indicate the need for a study that can identify the effect of the vaccination campaign. Oliveira et al. (2013) used the Serfling model[1] to identify Influenza outbreaks and estimate the mortality attributable to them. The authors found in the Northeast there was an increase in mortality from Influenza and pneumonia after vaccination, and in the South the post-vaccination period showed a reduction in mortality from Influenza and pneumonia and in the number and duration of Influenza outbreaks.

The Influenza vaccine impact literature faces two main challenges. First, several campaigns have low adherence, characterizing the presence of selection bias in the vaccinated group. The Brazilian Influenza Vaccination Campaign has high adherence rates, so this problem is not so serious in our context. Second, the vaccination campaign acts by two means: immunizing the target public and reducing the number of virus vectors in society. Thus, even those who were not vaccinated probably benefited from the campaign. This generates an attenuation effect when comparing groups vaccinated with unvaccinated groups. This attenuation effect may be responsible for such modest results in the literature. To address this problem, we analyzed mechanisms that may attenuate or amplify the effects of the vaccine.

[1]This method (Serfling, 1963) is a cyclic regression model, and is the standard CDC algorithm for flu detection.

3 Data

Data on various dimensions of hospitalization and mortality are available from the Brazilian Ministry of Health (Ministry of Health/Datasus). Our treatment variable is a dummy indicating if a given age group is eligible for vaccination for each year. We collapse the microdata to build an yearly panel of data at the micro-region of residence level for the 1996-2004[2]. Our dependent variables in this analysis are hospitalization and mortality rates per 1000 inhabitants by micro-region, age group and, cause of death. Our sample contains yearly data for 558 micro-regions over the 1996-2004 period.

First, we construct data on elderly hospitalization from microdata from the Hospital Information System of SUS (SIH/SUS). These data originated from the Authorizations of Hospital Admission (AIH) from public and private hospitals contracted with SUS. The SIH/SUS database covers about 80% of overall hospitalizations in Brazil (Pinheiro et al., 2001). These data are administrated by the Health Care Agency (SAS/Ministry of Health). This dataset contains cause of hospitalization, date of birth, and municipality of residence. We select all hospitalizations of individuals aged 55 years old up to 74. We separate the data into age groups of 5 years per micro-regions. We collapse the microdata to build an yearly panel for micro-regions residence level , each with data for 4 age groups, for the 1996-2004 period.

For the mortality analysis, we use data from microdata from the Brazilian National System of Mortality Records (SIM/Datasus). These data provide information on every death officially registered in Brazil. It provides information by cause of mortality, date of birth, and municipality of residence. As with SIH, we select all mortality of individuals aged 55 years old up to 74, and we separated the base into age groups of 5 years per micro-regions. We collapse the microdata to build an yearly panel for micro-regions residence level , each with data for 4 age groups, for the 1996-2004 period. We focus on a mortality analysis in the South and Southeast regions, because the mortality records in the other regions were still considered deficient by the 1990s (Paes and Albuquerque, 1999).

[2]The micro-region is a grouping of municipalities of the same state. It's a type of territorial division widely used by Brazilian Institute of Geography and Statistics (IBGE). Brazil has 558 micro-regions.

In order to account for the fact that the variance of mortality is strongly related to population size, we convert number of deaths and hospital admissions into micro-region rates. We use annual data on municipality population, by age obtained from Brazilian Census Bureau (IBGE, after Instituto Brasileiro de Geografia e Estatstica).

Finally, to investigate heterogeneities in the effects we also use some policy and demographic variables. To analyze the policy mechanisms, we use the intensity of the vaccine campaign, percentage of Brazils Family Health Program (PSF)[3] coverage, and governance index. We use Information System of the National Immunization Program (SI-PNI) to construct the campaign intensity variable. This database reports the information of all the vaccines applied in Brazil, by type of vaccine and municipality of residence. We construct the rate by dividing the number of Influenza vaccines applied over the eligible population to take the vaccine in the micro region, using annual data on municipality population (IBGE). The percentage of PSF coverage is obtained from the Department of Basic Attention from Brazilian Ministry of Health (DAB/Ministry of Health). We construct the health governance index[4] based on Hone et al. (2017) using 20012002 MUNIC (Basic Municipal Information Survey), which profiles Brazilian municipalities. These data come from the Brazilian Institute of Geography and Statistics (IBGE). To analyze the demographic mechanisms, we use the 2000 Brazilian Census Bureau. We use the log density and the percentage of residences in slums in the municipality. All variables are collapsed at the micro-region-by-year level, and merged with the other data containing health outcomes. Table 0 presents the descriptive statistics.

4 Empirical Strategy

We explore changes on the targeted audience of the Influenza vaccine campaign over time and adopt a difference-in-differences strategy. Our goal is analyze how implementation of the Influenza vaccine campaign impacts the cases of hospitalization and

[3]Project from the Brazilian Ministry of Health to target prevention and provision of basic health through the use of professional health-care teams intervening at the community

[4]Our measure of health governance was based on three binary indicators (scored 0 or 1) for each municipality. The indicator question if municipality has health fund, computerized health database, and Health council. If the municipality responds yes it receives 1, if it responds it does not receive 0. We added the dummies of the municipalities and collapsed the base by micro-region by calculating the weighted average of the population of the municipalities

mortality from respiratory diseases. Our unit of observation is an age group per micro-region at a point in time. Our main empirical specification is the following:

$$\text{Health}_{ijt} = \beta_0 + \beta_1 \text{Vaccine}_{it} + \text{X}_{jt} + \mu_{jt} + a_i + b_j + c_t + u_{ijt} \quad (1)$$

in which Health_{ijt} denotes hospitalization or mortality rates per 1000 inhabitants for age group i, micro-region j, in year t. Vaccine_{it} is a dummy variable assuming value 1 if age group i is eligible to receive the Influenza vaccine in year t. We control for micro-region characteristics, X_{jt}, and μ_{jt} is a linear micro-region trend.

We include fixed-effects to control for aggregate effects and for unobserved characteristics which are constant over time at the micro-region level. a_i is a age group fixed-effect, b_j is a micro-regions fixed-effects, and c_t is a year fixed-effects. The micro region fixed effects control for unobserved time-invariant characteristics at the micro region level. These effects absorb state fixed-effects. The year fixed-effect capture time trends, such as macroeconomic conditions and health policies that varied homogeneously among age x micro-region groups over time. The age group fixed-effect controls for unobserved heterogeneity at the age group level. The term u_{ijt} is a random error.

The micro-region initial conditions may be associated with a tendency toward convergence in health indicators, so that initially worse-off micro-regions naturally catch up to better-off ones. Therefore, we add linear micro-region trends in our empirical specification to control for dynamic characteristic of the dependent variable. The variable X_{jt} denotes the hospital-bed ratio per micro-region over time. Our micro-region control X_{jt} denotes hospital-bed ratio per micro-region over time. This term controls for the expansion occurred in the health system at the period. Finally, we cluster standard errors at the micro-region level to account for the possibility of serially correlated and heteroskedastic errors (Bertrand et al., 2004).

The identification of β is based on the hypothesis that conditional on fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region and states, the variable of interest is orthogonal to any other determinants of hospitalization or mortality by respiratory diseases. The Ministry of Health changed the age groups eligible to receive the Influenza vaccine without giving specific reasons, so we understand that there are no other determinants of hospitalization or mortality correlated with vaccine$_{it}$.

The human is the vector of Influenza virus, so when the vaccine is applied to a person, the vaccine is acting through two mechanisms. First, vaccine is immunizing the person receiving the vaccine, and it withdraws from society a possible vector of the Influenza virus. Second, Influenza vaccination campaign has an impact on people not eligible for vaccination, because reducing the number of potential Influenza vectors and consequently decreasing the likelihood of a person of any age being infected with the Influenza virus. This is characterized by an spillover effect of the vaccination campaign. In that case, this effect can act by attenuating the effect estimated by our identification strategy, because both the treatment group and the control group are impacted by the vaccination campaign. For this reason, we interact the treatment variable $vaccine_{it}$ with political and demographic mechanisms that affect the environment in which vaccination was applied, which leads to the estimation of the following equation:

$$\text{Health}_{ijt} = \beta_0 + \beta_1 \text{Vaccine}_{it} + \beta_2(\text{Vaccine}_{it} \times Mech_{jt}) + \beta_3(\text{afterV}_t \times \text{Mech}_{jt})$$
$$+ \text{Mech}_{jt} + \text{X}_{jt} + \mu_{jt} + a_i + b_j + c_t + u_{ijt}\text{c}$$
(2)

The triple-interaction between year, age group and mechanisms, $\text{Vaccine}_{it} \times \text{Mech}_{jt}$, is our variable of interest to analyze mechanisms effects. We also include in the regressions the double-interactions between mechanisms variables and time, $\text{afterV}_t \times \text{Mech}_{jt}$, and only the mechanisms variables, Mech_{jt}.

Finally, previous research has documented a heterogeneous effect of the Influenza vaccine campaign on hospitalization and mortality according to the geographic region in Brazil (Daufenbach et al., 2009). We take advantage of the fact that Brazil is a country with larger geographical and demographic differences between macro-regions and we explore the heterogeneities in the effect of the Influenza vaccine among macro-regions. We estimate the impact of Influenza for each macro-region separately. We also estimate the effect of the Influenza vaccination campaign per season, to explore the heterogeneity of climatic variations over the year. Figure 1 shows trends in hospitalization rates in the period 1996-2004 for the Treatment and Control groups. Figure 1 shows the seasonal tendency of hospitalization rates. The first vertical line indicates when the campaign starts, the second line indicates the extension of the treatment group. Figure 2 shows the difference in hospitalization rates between the treatment and control groups, the difference between groups decreases after the start of the vaccination campaign.

5 Results

5.1 Main Results

First, we present the results of the effect of Influenza vaccine on hospitalization rates from respiratory diseases per 1000 inhabitants for Brazil, from the estimation of equation 1. We then present estimates of equation 1 for each geographic region and each season. After that, we show estimates of equation 2, in which we interact our treatment variable with different policy and demographic mechanisms. Finally, we present the results of estimation of equation 1 with mortality rates from respiratory diseases as dependent variable.

In column 1 of Panel A of Table 1, we examine the effect of Influenza vaccine on hospitalization rates by respiratory diseases with micro-regions, age groups and year fixed-effects, but without infrastructure and time trends. We include micro-regions control for infrastructure in column 2. In order to control for convergence in health, we report the results when including nonlinear state trends in column 3, and in column 4 we remove the state nonlinear trend and include a micro-region linear trend. In all of the regressions in Table 1, we cluster standard errors at the micro-region level to allow for intra-micro-region serial correlation over time (micro-region cluster).

The results we show on Panel A of Table 1 indicate negative and significant effects of the Influenza vaccine on hospitalization rate in Brazil. The estimate in column 4 is -1.93, which represents a negative effect of 6% of the average respiratory hospitalization rate per 1000 inhabitants. The effect remains unchanged when we add infrastructure controls and trends that capture convergence in health indicators.

In panel B of table 1, we run a placebo test. We repeat the same regressions based on Panel A, but now the dependent variable is the hospitalization rate from external causes per 1000 inhabitants. In Panel B of Table 1 no column shows significant results, this indicates that the effect we observe in reducing hospitalization rates from respiratory diseases is caused by the vaccination campaign.

5.2 Heterogeneous effects

Overall, the results we have shown up to this point indicate that the Influenza vaccine campaign reduces hospitalization rates from respiratory diseases in Brazil. Daufenbach et al. (2009) describes the different trends in health indicators between macro-regions and seasons in Brazil. So we split our estimations between different macro-regions and seasons.

In Table 2 we show the estimates of equation 1 per macro-region with fixed effects of micro-regions, age group and time, controls for health infrastructure and specific trends of micro-region and states. In panel A, we present the results of the regressions by macro-region with hospitalization rates from respiratory diseases as a dependent variable. We find negative and significant estimates for Northeast, Southeast and South. In the Northeast, the effect of vaccination is a reduction of 4% in hospitalization rates from respiratory diseases. The effect of the vaccine on the hospitalization rate from respiratory diseases in the Southeast is a reduction of 11%, and in the South a reduction of 8%. We do not find significant effects in the North and Midwest regions. In panel B of table 2, we run a placebo test with hospitalization rates for external cause as dependent variable and we not find significant results for any region.

The Brazilian Influenza Vaccination Campaign occurs every year in the months of April and May. Next, we discard these months from the analysis. We consider the months of June, July, August, and September as Winter. We call Spring the months of October, November, and December. Finally, we call Summer/Fall the months of January, February and March. In Panel A of Table 3 we show significant effects only for Winter and Spring seasons, the Influenza vaccine reducing the hospitalization rates in Winter in 13%, and 3% in the Spring.

In order to analyze the impact of policy and demographic mechanisms in the effect of the Influenza vaccination campaign, we estimate equation 2. We focus this analysis only in the South and Southeast regions, because these are the regions in which the impact of the Influenza vaccine in hospitalizations rates is more relevant. In table 4 we present the results of interaction between Influenza vaccine and policy mechanisms. We present in Column 1 the impact of the Influenza vaccine grouping the South and Southeast regions together, and without considering interactions of the treatment with other variables, the Influenza vaccine coefficient is -3.30 and indicates a decrease of 11% in hospitalization rates per 1000 inhabitants from respiratory diseases. In columns with interaction, the interpretation depends on the two coefficients. We present in Column 2 the result for interaction of the campaign variable with population density, relative to the mean of vaccination rate, the hospitalization rates from respiratory diseases decrease 11%. In Column 3 we show the result for interaction with the percentage of families covered by the PSF in the micro-region. We not find effect in this interaction. In Column 4 we show that when we interact the vaccine with governance variable. We not find effect in this interaction. Finally, in column 5 we present together all political mechanisms, only interaction with vaccination rates remains significant, in this situation the Influenza vaccination reduces hospitalization rates by 10%.

We present in table 5 the results of estimates between Influenza vaccine and demographics mechanisms. In Column 1 we indicate the same of table 4. In Column 2 we show the interaction with Influenza vaccine and density, and in Column 3 we present the interaction with Influenza vaccine and percentage of residences in slums by micro-region. In Column 4 we show together all demographic mechanisms. We find that the effect of the campaign on hospitalization rates is larger where the population density is higher, and where there are more people living in slums. Finally, in table 6, we analyze the impact of

Influenza vaccination on mortality by respiratory diseases. We estimate equation 1 with the dependent variable as death rate from respiratory diseases. In column 1, we control for the infrastructure of the health system in each micro region, and also for a non-linear state trend. In column 2, we replace the non-linear state trends by linear micro-region trends. The result indicates negative effect of 7% in the mortality rate due to respiratory diseases in the South and Southeast. For the whole sample the effect is not significant. In panel B of table 6, we do a placebo test, similar than panel B of table 1. We repeat the same regressions based on Panel A of table 1, but now the dependent variable is the hospitalization rate for external causes per 1000 inhabitants. In panel B of table 6 no column shows significant results.

6 Conclusion

This paper examines the effect of the Brazilian National Influenza Immunization Program on hospitalization and mortality rates from respiratory diseases in the elderly. We find that the Influenza vaccination campaign reduces hospitalization rates per 1000 inhabitants in 6%. The effect of the Influenza campaign is bigger in the South and Southeast regions, and in the Winter and Spring seasons. The Influenza campaign decreases in 8% the hospitalization rates for respiratory diseases per 1000 inhabitants in South, and 11% in Southeast. When we analyze only the South and Southeast regions, we find a decrease of about 7% on mortality rates. We also find that the effect of the campaign on hospitalization rates is larger where the population density is higher, where there are more people living in slums, and where the penetration of other health programs is also higher.

Overall, we find that the Brazilian National Influenza Immunization is effective in reducing the number of complications caused by the Influenza virus. We find that this effect is mainly concentrated in the South and Southeast. So we believe that policy makers need to discuss institutional changes in the campaign in order to adapt the Influenza vaccination campaign to affect all macro-regions in the Brazil.

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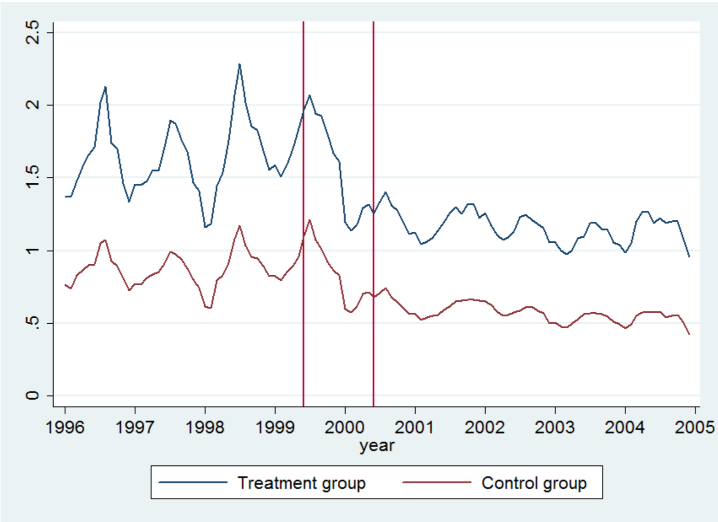
Table 0 - Descriptive Statistics
Panel A - dependent variables (1996-1998)

	Observations	Mean	Std. Dev.	Min	Max
Hospitalization rate for respiratory	6696	34.30	26.95	0	292
Hospitalization rate for external	6696	5.50	2.95	0	25.64
Mortality rate for respiratory	6696	1.70	1.91	0	16.69
Mortality rate for external	6696	0.72	0.68	0	11.81

Table 0 - Descriptive Statistics
Panel B - controls e mechanism variables (1996-2004)

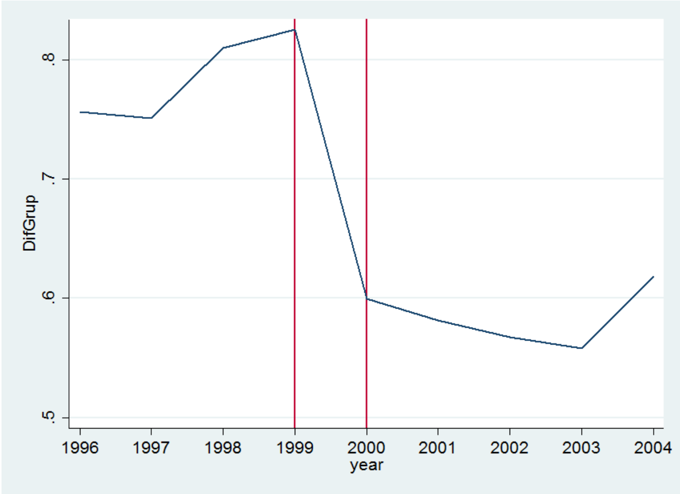
	Observations	Mean	Std. Dev.	Min	Max
Hospital-bed ratio	20088	0.40	0.43	0	5.00
Vaccination rate	20088	0.73	0.57	0	6.84
PSF coverage	20088	0.44	0.43	0	1
Governance (gov)	20088	2.47	0.36	1	3
log Density	20088	3.21	1.51	-1.49	8.60
% Residences on the outskirts	20088	0.007	0.02	0	0.42

Figure 1: hospitalization rates from respiratory diseases - Brazil (1996-2004)



Notes: Difference in hospitalization rates between the treatment and control groups by month-year.

Figure 2: Difference across treatment and control group - hospitalization rates from respiratory diseases - Brazil (1996-2004)



Notes: Difference in hospitalization rates between the treatment and control groups by year.

Table 1 - Influenza vaccine effect on hospitalizations rates (Brazil)
Panel A - dependent variable: hospitalization rates from respiratory diseases

	(1)	(2)	(3)	(4)
Vaccine	**-1.93*****	**-1.93*****	**-1.93*****	**-1.93*****
	(0.34)	**(0.34)**	**(0.32)**	**(0.31)**
Dependent variable mean	30.64	30.64	30.64	30.64
Controls	No	Yes	Yes	Yes
Non-linear state trend	No	No	Yes	No
Linear micro-region trend	No	No	No	Yes
Observations	20,088	20,088	20,088	20,088
R-squared	0.788	0.788	0.811	0.822

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004.

Panel B - dependent variable: hospitalization rates from external causes

	(1)	(2)	(3)	(4)
Vaccine	**-0.027**	**-0.027**	**-0.027**	**-0.026**
	(0.074)	**(0.073)**	**(0.070)**	**(0.056)**
Dependent variable mean	6.09	6.09	6.09	6.09
R-squared	0.048	0.049	0.081	0.180

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004.

Table 2 - Effect of the vaccine on hospitalizations rates (per macro-region)
Panel A - dependent variable: hospitalization rates from respiratory diseases

	North	Northeast	Southeast	South	Midwest
	(1)	(2)	(3)	(4)	(5)
Vaccine	**0.49**	**-0.93*** **	**-2.66*** **	**-4.32*** **	**-1.80**
	(0.69)	**(0.28)**	**(0.27)**	**(0.76)**	**(1.24)**
Dependent variable mean	22.96	21.62	24.93	53.46	49.04
Non-linear state trend	No	No	Yes	No	Yes
Linear micro-region trend	No	No	No	Yes	Yes
Observations	2,304	6,768	5,760	3,348	1,872
R-squared	0.471	0.373	0.497	0.575	0.383

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region and states.

Panel B - dependent variable: hospitalization rates from external causes

	North	Northeast	Southeast	South	Midwest
	(1)	(2)	(3)	(4)	(5)
Vaccine	**-0.0064**	**-0.13**	**-0.093**	**0.18**	**0.14**
	(0.17)	**(0.10)**	**(0.091)**	**(0.13)**	**(0.19)**
Dependent variable mean	5.06	4.67	7.19	7.30	6.86
R-squared	0.178	0.126	0.159	0.283	0.246

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region

Table 3 - Effect of the vaccine on hospitalizations rates (per season)
Panel A - dependent variable: hospitalization rates from respiratory diseases

	Summer/Fall	Winter	Spring
	(1)	(2)	(3)
Vaccine	**0.034**	**-1.54*****	**-0.24*****
	(0.070)	**(0.11)**	(0.073)
Dependent variable mean	6.79	11.40	7.37
Controle tendncia uf/microrregio	Sim	Sim	Sim
Observaes	20,088	20,088	20,088
R-squared	0.191	0.425	0.245
Nmero de grupos etrios	2,232	2,232	2,232

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region

Panel B - dependent variable: hospitalization rates from external causes

	Summer/Fall	Winter	Spring
	(1)	(2)	(3)
Vaccine	**0.0066**	**-0.0020**	**-0.012**
	(0.023)	**(0.029)**	**(0.024)**
Dependent variable mean	1.45	2.06	1.56
micro-region trends	Yes	Yes	Yes
Observations	20,088	20,088	20,088
R-squared	0.104	0.098	0.082

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region

Table 4 - Policy mechanisms (South/Southest)
Panel A - dependent variable: hospitalization rates from respiratory diseases

	(1)	(2)	(3)	(4)	(5)
vaccine	-3.30***	0.27	-2.53***	-2.27	2.44
	(0.30)	(1.48)	(0.70)	(4.80)	(5.11)
vaccine*vaccination_rate		-3.32***			-3.22***
		(1.32)			(1.32)
vaccine*PSF			-1.46		-1.25
			(1.29)		(1.31)
vaccine*gov				-0.41	-0.64
				(1.91)	(1.92)
Dependent variable mean	30.64	30.64	30.64	30.64	30.64
Observations	9,144	9,144	9,144	9,144	9,144
R-squared	0.859	0.860	0.859	0.859	0.860

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region

Table 5 - Demographic mechanisms (South/Southest)
Panel A - dependent variable: hospitalization rates from respiratory diseases

	(1)	(2)	(3)	(4)
vaccine	-3.30***	8.18***	-2.33***	5.99***
	(0.30)	(1.01)	(0.34)	(1.13)
vaccine*density		-3.01***		-2.31***
		(0.49)		(0.62)
vaccine*%Slums			-111***	-56.1***
			(13.7)	(16.6)
Dependent variable mean	30.64	30.64	30.64	30.64
Observations	9,144	9,144	9,144	9,144
R-squared	0.859	0.862	0.861	0.862

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include fixed effects of micro-regions, age group and time, health infrastructure and specific trends of micro-region

Table 6 - Effect of the vaccine on mortality

Panel A - dependent variable: mortality from respiratory diseases				
	Brazil		South/Southest	
	(1)	(2)	(3)	(4)
Vaccine	**-0.013**	**-0.013**	**-0.16*****	**-0.16*****
	(0.022)	**(0.024)**	**(0.034)**	**(0.034)**
Dependent Variable mean	1.69	1.69	2.46	2.46
Non-linear state trend	Yes	No	Yes	No
Linear micro-region trend	No	Yes	No	Yes
Observations	20,088	20,088	9,144	9,144
R-squared	0.011	0.011	0.042	0.042

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include controls.

Panel B - dependent variable: mortality for external causes				
	Brazil		South/Southest	
	(1)	(2)	(3)	(4)
Vaccine	**0.0059**	**0.0059**	**0.015**	**0.015**
	(0.018)	**(0.018)**	**(0.022)**	**(0.022)**
Dependent variable mean	0.74	0.74	0.82	0.82
R-squared	0.011	0.011	0.042	0.042

Notes: Standard errors in parentheses, clustered at the micro-region level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The estimated coefficients and their respective standard errors were defined as in equation 1. Our sample covers the interval between 1996 and 2004. All specifications include controls