EVALUATING THE IMPACT OF PHYSICIANS' PROVISION ON PRIMARY HEALTHCARE: EVIDENCE FROM BRAZIL'S MORE DOCTORS PROGRAM

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Abstract

This study aims to evaluate the More Doctors Program (*Programa Mais Médicos* – PMM) in terms of the provision of physicians, presenting estimates of its impact on hospitalization for ambulatory care sensitive conditions (ACSH). The differences-in-differences method was used with propensity score matching (double difference matching), using three specifications, a falsification test and also a dynamic endogeneity test to confirm the robustness of the results. For the application of this methodology, a panel of municipal data was constructed covering several variables related to socioeconomic, demographic and public health infrastructure characteristics in the cities for the period from 2010 to 2016. The results show a significant reduction in hospital admissions in treated municipalities with an increasing and perceptible effect in the second year of the program.

JEL classification: I12; I18; O5

Key Words: More Doctors Program; Hospitalizations for conditions sensitive to primary care (ACSH); Differences-in-differences; Propensity Score Matching.

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1 Introduction

The inadequate supply and poor geographical allocation of health professionals and services are problems that affect many countries in the world, regardless of their level of economic development. It is one of the major challenges faced by OECD countries in terms of public policy formulation, according to the OECD report (2016). For the United States, the AAMC study (2016) estimates that the demand for doctors has been growing at a higher rate than the supply, which may cause a deficit of 94.700 professionals in 2025.

In remote areas, the problem may be even more serious and difficult to solve if we take into account the attraction and retention of doctors. Most of these professionals prefer to live in urban areas because of greater professional and educational opportunities and higher quality of life. As a result, there is a mismatch between the geographical distribution of physicians and the demand for them (Ono, Schoenstein, & Buchan 2014). This situation affects negatively the accessibility to health services and, consequently, population health indicators.

Programs such as the Overseas Trained Doctors in Australia, the National Health Services Loan Repayment Program in the United States, and the *Mission Barrio Adentro* in Venezuela are examples of public policies that have been implemented to address the problem of scarcity and inequalities in the distribution of physicians. The recruitment of foreign-trained physicians has been a common strategy among OECD countries in order to overcome this problem, especially because of the long time required to train new doctors (Moullan & Chojnicki 2017). Recent data show that around 35% of the UK's registered doctors were trained abroad, while this rate is 33% in Canada and 27% in the USA (Siyam & Dal Poz 2014).

However, as the OECD (2016) points out, there is little causal evidence of the impact of these policies on population health indicators. Evaluations of these programs have emphasized their monitoring or have used qualitative approaches, highlighting the debate surrounding the launch of the programs and the historical context of their implementation in the countries (Dolea, Stormont & Braichet 2010; Bärnighausen & Bloom 2009).

In Brazil, several initiatives have been implemented by the government since the creation of the Unified Health System (UHS) in order to increase the population's access to health services, especially in the most remote and deprived areas. Among these measures, the Community Health Agents Program implemented in 1991 and the Family Health Program implemented in 1994 are highlighted. Both had the objective of reorganizing the public health system through the performance of health teams in communities, aiming at the prevention, diagnosis and treatment of diseases.

The literature on the subject indicates that such programs have transformed the health care provision in Brazil, moving away from a hospital-centered regime in the main urban areas of the country towards a decentralized model, in which the first point of contact between the health system and the population became the health teams. These changes represented a notable advance in UHS coverage by ensuring the inclusion of a large number of poor families in the primary care assistance network (Macinko, Guanais, & Cimões 2008, Rocha & Soares 2010).

Despite the advances, the restriction in the supply of doctors in less developed regions prevented a greater strengthening of public health care coverage. An OECD study (2013) for a sample of forty-three countries showed that Brazil was the seventh worst place in terms of the number of doctors per thousand inhabitants, being well below several countries in Latin America. According to a survey by the Institute for

Applied Economic Research (IPEA 2010), the problem was even more serious because of regional disparities in physician allocation. In several cities in the North and Northeast of Brazil, there was not even one doctor per thousand inhabitants, making it difficult for the population to access healthcare.

In this context, the More Doctors Program (*Programa Mais Médicos* - PMM) was launched in 2013 aiming to solve the main problem of the UHS, the lack of doctors. The program was constituted through three pillars of action: i) the emergency provision of doctors to work in primary care, prioritizing the municipalities with the greatest deficit of professionals, ii) the improvement of the infrastructure of Basic Health Units (BHU) and services, and iii) the increase in the number of admissions to medical courses in locations with greater need of physicians and fewer vacancies per capita.

In 2016, More Doctors completed its third year of existence and since its creation has been motivating countless debates and analysis among researchers. In the studies already carried out, the greatest emphasis was placed on its implementation and effectiveness in terms of coverage, access and equity (Girardi et al. 2016; de Sousa Lima et al. 2016; Oliveira, Sanchez, & Santos 2016). Limitations and criticisms of PMM and the formation of physicians were also addressed in a study by Kemper, Mendonça, & Souza (2016). Regarding the evaluation of the program, only the works of Bento da Silva et al. (2016) and Santos et al. (2017) were found. The former analyzed the satisfaction with the program from the point of view of the healthcare system users and the latter the trend of avoidable hospitalizations before and after PMM.

This article contributes to this literature by presenting an evaluation of the More Doctors Program on the variable of hospitalization for ambulatory care sensitive conditions (ACSH) in the period between 2010 and 2016. Although there are other health indicators that could be evaluated, we chose ACSH for two reasons. The first is related to the fact that this variable represents not only the level of health services coverage, but also the degree of resolutiveness of primary care (Bindman et al. 1995, Starfield, Shi, & Macinko 2005, Ansari, Laditka, & Laditka 2006). The second is due to Ordinance nº. 221 of 2008 of the Ministry of Health, which defines hospitalizations for ambulatory care sensitive conditions as the main indicator for monitoring and evaluation of basic care policies in Brazil. Moreover, this indicator is the most recommended for measuring the impact and effectiveness of PMM according to a 2015 specific audit report about the program of the Brazilian Federal Court of Accounts (TCU – Brazil).

The results found in the present study show that there was a reduction in hospital admissions in the treated municipalities from the second year of PMM on, evidencing that the provision and the reallocation of physicians can positively impact the performance of the basic health system in Brazil.

2 More Doctors Program and The Emergency Provision

The More Doctors Program (PMM) was created by Provisional Measure n°. 621 of July 2013 and regulated by Law n°. 12.871 with the objective of "reducing the shortage of doctors in the priority regions for the UHS in order to reduce regional inequalities in healthcare" (BRAZIL, 2015, p.1). In order to increase physicians' supply, government has established the Emergency Provision, called "More Doctors Project for Brazil". It is expected that until 2020 the mark of 2.5 doctors per thousand inhabitants will be reached (Brazilian Ministry of Health, 2015).

All municipalities may voluntarily apply for membership in the program.

Nonetheless, faced with the shortage of medical professionals in deprived areas, priority criteria were defined among participating cities[2]. The hiring of physicians is performed through public call notices, which establish a priority for Brazilian doctors. If they do not fill all the vacancies, the program envisages the recruitment of professionals trained in other countries. According to the Ministry of Health, about 62% of PMM physicians are Cubans.

Before they actually serve through the program, PMM physicans undergo a three-week long training about the epidemiological and cultural profile of the regions where they are going to work at. Due to program rules, physicians must work as family doctors or generalists. They work directly in BHU, meeting a weekly workload of 40 hours, with 32 hours reserved for medical activities and 8 hours for attending a specialization course on primary care[3]. In addition, they must be advised by a senior professional whose responsibility is to monitor and support the new doctors.

The doctors earn a monthly wage of US$ 3,684.04, paid by the federal government. The local government is responsible for providing board, lodging and food benefits, which varies from around US$ 300 to US$ 1,000. Data about PMM implementation reveal that the program cost US$ 732 milions in 2016.

The More Doctors Program has undergone a rapid expansion both in the number of doctors incorporated and in the number of cities served. According to Ministry of Health data, 2,101 cities were already beneficiary of PMM by December 2013. In July 2014, coverage reached 3,490 municipalities with a total of 14,106 active physicians. Currently, PMM guarantees healthcare to about 63 million people.

Regarding the regional disparities in the allocation of physicians, until September 2014, there was a reduction of 53% in the number of municipalities with a shortage of these professionals. In the North, 91% of municipalities that had a small number of doctors joined PMM (Santos, Costa, & Girardi 2015). Moreover, 82% of the municipalities with 20% or more of the population living in extreme poverty participate the program (Brazilian Ministry of Health 2015).

3 Data and Identification Strategy

In the impact analysis, a municipal panel data, which comprises August 2010 to July 2016[4] is used, totaling six years - three years after and three years before PMM. The panel includes variables related to public health and socioeconomic characteristics, whose detailed descriptions can be seen in Table A1 of Appendix A, where other informations about the database are also presented.

[2] Municipalities with a percentage of the population in extreme poverty equal to or higher than 20%, with low or very low Human Development Index (HDI), and members of regions such as the Semi-arid, North with scarcity, Jequitinhonha, Mucuri and Ribeira, vulnerable capitals and metropolitan areas and municipalities included in the G100 index, Special Indigenous Sanitary Districts (Brazilian Ministry of Health, 2015).

[3] The doctors of PMM may also work as part of the Family Health Program teams, which visit households and follow families through time on a recurrent basis, teaching better practices and promoting change of habits (handling and preparation of foods, diet, cleanliness, strategies to deal with simple health conditions etc).

[4] The program was created in July 2013, however it was in August of the same year that new doctors began to be incorporated. In this article, the periods of analysis are then composed of August of a base year and July of the following year, totaling twelve months for each period. In this way, we can analyze the three years of the program: August 2013 to July 2014, August 2014 to July 2015 and August 2015 to July 2016.

Since most of the municipalities that joined PMM did so until July 2014 (92%)[5], it was decided not to use a staggered approach that would consider different times of entry into the program. In this case, the cities that became part of PMM in the second and third year of the program were excluded from the analysis. This strategy did not cause many losses and made it possible to follow a specific cohort of municipalities over time. The final sample is made up of 5,269 municipalities[6].

The great adhesion of cities in the first year of the program brought questions about PMM's ability to generate the expected results by including a profile of non-priority municipalities (Oliveira, Sanchez, & Santos 2016), which constituted a quite heterogeneous treatment group. Considering that this group is formed by 3,490 municipalities and given the heterogeneity already mentioned, we tried to identify the municipalities that would potentially be most affected by the intervention. In the literature, the same concern was present in the work of Santos et al. (2017), who chose as treatment group only municipalities with 20% or more of the population living in extreme poverty, as well as those located in border areas.

Our identification strategy considers as treated the municipalities that experienced a significant change of scale in doctors' supply because of the program. In this way, it aims to identify the priority municipalities in line with the objective of PMM, whose purpose was to increase the proportion of physicians by inhabitants and focus them in the poorest regions in terms of health care. To select such municipalities, we used the ratio between the number of PMM physicians and the total number of physicians in the year prior to the intervention as a measure of scale. This measure considers not only the number of doctors of the program received by the municipality, but also their lack of these professionals. From its calculation for each municipality, we defined as the most affected by the program those with variation in the supply of physicians corresponding to the last quartile of the distribution of this measure[7].

The control group, in turn, was composed of municipalities that did not receive doctors linked to the More Doctors Program. The municipalities that received PMM physicians, but in a smaller proportion compared to the treatment group make up a group that will be used as pseudo-placebo to test the robustness of the results. Since these municipalities did not experience a significant change in physicians' supply, it is expected that PMM would not impact the outcome variable of this group. The descriptive statistics presented below (Table 1) show that the pseudo-placebo group had, on average, 7% variation in the physician scale versus 38% among the treated municipalities, suggesting that the treatment group may actually have been the most affected by the intervention.

In addition, the municipalities that make up the treatment group had an average of 0.93 doctors per thousand inhabitants one year before the program. It is a proportion below the minimum density recommended by the Ministry of Health (one per thousand inhabitants). In turn, the mean proportion of the pseudo-placebo group was 2.79 doctors per thousand inhabitants. A figure that is above the goal set by the Ministry of Health of 2.5 doctors for the Brazilian municipalities in 2020. Table 1 also shows that the treated municipalities are considered the worst in socioeconomic and public health conditions, both in relation to the pseudo-placebo and to the control group.

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[5] 3,789 municipalities joined the program during its first three years, of which 3,490 joined PMM in the first year.

[6] 95% of the total number of Brazilian municipalities.

[7] This group corresponds to the cities that received PMM doctors in a proportion equal to or greater than the 15.4% (lower limit of the quartile) of the number of physicians that had already been serving the municipalities.

On average, these municipalities presented a smaller number of doctors, beds, professionals, and health equipments compared to the other groups of analysis. In regard to socioeconomic conditions, they have higher per capita value of transfers linked to the Bolsa Família Program, lower GDP per capita, lower average salary, and lower occupancy rate. In addition, they have the highest percentage of households with open garbage and lower percentage of households with electric energy.

Table 1: Descriptive statistics for treatment, pseudo-placebo and control groups, one year before PMM

Variable	Treated			Pseudo-Placebo			Control		
	Obs	Mean	Std. Dv.	Obs	Mean	Std. Dv.	Obs	Mean	Std. Dv.
ACSH	1,322	11.7	9.17	2,168	14.49	9.70	1,779	13.38	9.99
Physicians	1,322	0.93	0.55	2,168	2.79	2.28	1,779	1.96	1.60
Health Professionals	1,322	2.91	1.48	2,168	4.08	1.93	1,779	4.09	1.98
Beds	1,322	0.90	1.35	2,168	2.32	1.99	1,779	1.51	2.18
Health Facilities	1,322	0.87	0.46	2,168	1.26	0.70	1,779	1.17	0.61
Health Equipments	1,322	0.17	0.25	2,168	0.41	0.32	1,779	0.31	0.33
Schools	1,322	3.19	1.76	2,168	1.93	1.22	1,779	2.54	1.72
Open Garbage	1,306	0.15	0.17	2,087	0.07	0.11	1,719	0.09	0.14
Energy	1,306	0.90	0.12	2,087	0.96	0.07	1,719	0.96	0.08
Untreated Water	1,306	0.34	0.28	2,087	0.37	0.30	1,719	0.34	0.31
Average Wages	1,322	1.82	0.45	2,168	2.05	0.59	1,779	1.94	0.56
Occupancy rate	1,322	0.11	0.15	2,168	0.19	0.14	1,779	0.21	0.75
PBF *per capita*	1,322	3.19	0.73	2,168	2.58	0.85	1,779	2.67	0.87
GDP *per capita*	1,307	9.30	0.71	2,146	9.56	0.72	1,758	9.49	0.70
Δ Physicians scale*	1,322	0.38	0.29	2,168	0.07	0.05	1,779	-	-
Population	1,307	12,790	13,460	2,168	67,380	325,472	1,779	12,343	20,856

Note: (*) Ratio between the number of PMM physicians and the total number of physicians in the city one year before the program.

Table A.2 in the Appendix shows the regional distribution of the municipalities for each group. It can be noted that among the cities of North and Northeast region, the treated municipalities represent 53.2% and 32.2%, respectively. These are the most deprived and poor areas in Brazil in terms of socioeconomic characteristics and, as already pointed out before, they also face greater accessibility difficulties to health services (IPEA 2010). The characteristics of the treatment group suggest that this group is in agreement with the priority municipalities of the program.

4 Empirical Strategy

To estimate the impact of the More Doctors Program on ACSH, we will use the differences-in-differences method weighted by propensity scores (double difference matching). While differences-in-differences method aims to reduce possible selection biases by unobservable characteristics, propensity score matching (PSM), by matching similar municipalities, minimizes possible biases by cause of the distribution of observable characteristics and lack of common support (Heckman, Ichimura & Todd 1997).

4.1 Propensity Score Matching

In PSM we used a Logit model to estimate the probability of the municipalities being part of PMM given a vector of characteristics of the period before the treatment ($X_{i,-1}$). This vector is composed of socioeconomic, regional, public health infrastructure, basic sanitation and local labor market characteristics of each municipality.

The matching by variables related to the previous period is necessary because of the great adhesion of municipalities to PMM in 2013. With this we avoided to distort the results since the characteristics of the municipalities could have been affected by the intervention already in the initial year of the program.

The propensity score, formally defined as $\widehat{\mathrm{P}}(\mathrm{X}) = \Pr\left(PMM_{i,0} = 1 \mid X_{i,-1}\right)$, will be used to compute weights in order to balance the municipalities, making the control group, on average, similar to the treated. In the matching, kernel estimator[8] will be used. To test matching balancing two evaluation criteria will be adopted: the first checks the overlap of the distribution of the treatment probability for both groups and the second refers to the t-test for equality of means between treatmeant and control groups before and after matching[9].

4.2 Differences-in-differences

The differences-in-differences method requires information from the treated and control units before and after the program. The effect of the intervention is captured by the difference in the difference of the results, for treated and controls, before and after treatment. In this way, it is aimed to control unobservable effects related to time and differences between the groups.

Denoting *t=1* as the period after the program and t=0 as the previous one, the difference-in-differences estimator is given by:

$$DD_i = E[(Y_{i1}^1 - Y_{i0}^1) - \left(Y_{j1}^0 - Y_{j0}^0\right) \quad (1)$$

where Y_i and Y_j are the outcome variable of a treated municipality i and control j, respectively.

4.3 Double Difference Matching

After matching, the differences-in-differences model, weighted by the results obtained with the PSM, estimates the impact of the treatment in the matched municipalities within a common support (denoted as C). Considering two time periods, the DDM_i

[8] The matching was also tested by the nearest neighbor method, with similarly satisfactory results. However, by cause of the significant reduction of the sample as a result of the mechanism inherent in this matching process, a non-parametric (kernel) technique was chosen.

[9] Possible biases for selection by observable characteristics will be mitigated as these criteria have been met.

estimate for each treatment municipality i is calculated by:

$$DDM_i = E[(Y_{i1}^1 - Y_{io}^1) - \sum_{j \in C} W_{ij}(Y_{j1}^0 - Y_{j0}^0)] \quad (2)$$

where W_{ij} is the weight given to a control municipality j, matched to a treatment municipality i. The weights are equal to 1 for the treated and $\frac{\hat{P}(X)}{1-\hat{P}(X)}$ for the controls.

To capture DDM_i we estimate the following equation, weighted by the PSM weights:

$$ACSH_{it} = \gamma + \beta(Post\,PMM_{it} \times PMM_i) + \theta_i + \alpha_s \times t + \varepsilon_{it} \quad (3)$$

where $ACSH_{it}$ is the number of ambulatory care sensistive hospitalizations per thousands inhabitants for municipality i and year t, Post $\mathrm{PMM_{it}}$ is a dummy variable for the period after the intervention, $\mathrm{PMM_i}$ is a dummy that indicates whether the municipality joined in PMM, θ_i represents municipality fixed effects, $\alpha_s \times t$ is a state-specific linear time trend and ε_{it} is an error term. The coefficient of interest is β, which corresponds to DDM_i and is estimated by OLS.

We also use a more flexible specification, where DDM_i is estimated for each year before and after PMM[10]. Formally, it can be written as:

$$ACSH_{it} = \gamma + \sum_{j=1}^{5} \beta_j(Year_j \times PMM_i) + \theta_i + \alpha_s \times t + \varepsilon_{it} \quad (4)$$

where $Year_j$ represents a dummy variable for each year between 2010 and 2016, except for the omitted category. All models use standard errors clustered at the municipal level seeking to account for serial correlated errors (Bertrand, Duflo & Mullainatha 2004)[11].

Considering that the adoption of PMM may depend on the health care preconditions of the municipality or its performance over time, the treatment variable may be endogenous. If the treatment variable is correlated only contemporaneously with the dependent variable, the use of fixed effects in the double difference-matching model could solve the problem. However, endogeneity may be worrisome if PMM adoption is related to the dynamics of the dependent variable, such as when municipalities that were already experiencing improvement in health indicators (in this case, ACSH) are precisely those with a higher probability of participating in the program. This situation would make sense because of the self-selective character of the adhesion process of municipalities into the PMM, which could end up sending doctors to the cities whose governments have better planning capacity and proactive behavior related to health care.

To estimate the extent of concern with dynamic endogeneity, we follow the procedure of Galiani et al. (2005), which consists in estimating the probability of participation in treatment as a function of the outcome variable in level and variation for the period prior to treatment. In addition, we also considered the independent variables, both in level and variation.

[10] According to Duflo (2001), the coefficients for years prior to treatment serve as a robustness test to assess whether in fact the estimated results are a reflection of the program or other shocks that affect treated and control units differently throughout the time.

[11] We also estimated regressions considering controls for contemporaneous values of municipality characteristics. The results are very similar to those in Section 5, but we do not present them (available upon request) due to the potential problem of "bad controls" (Angrist & Pischke 2009).

5 Results

In order to explore the effects of the program on variables directly related to its implementation, we present in Table 2 an auxiliary estimation in a differences-in-differences approach that considers as an outcome the number of physicians in a specification and in another the number of health equipments in the municipality[12].

Table 2: Impact of PMM on number of physicians and health equipments for all municipalities that received program's doctors, for treatment and pseudo-placebo groups

	All		Treated		Pseudo-Placebo	
	(1)	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
Post PMM	0.062**	0.005	0.127**	0.003	0.021	0.006
	(0.014)	(0.003)	(0.015)	(0.005)	(0.016)	(0.003)
Observations	31,614	31,614	17,808	17,808	23,682	23,682
Adjusted R^2	0.95	0.83	0.95	0.81	0.91	0.83

Note: Significant at 1% (**) and 5% (*). Column (1) refers to the number of doctors and column (2) to the health equipments. Regressions include municipality fixed effects and state-specific linear time trends. Standard errors (in parentheses) clustered at the municipality level.

Considering all municipalities that joined PMM, the estimated coefficient suggest an increase of 0.062 doctors per thousand inhabitants in the post-program period compared to the group of non-participating PMM cities. The estimated effect is equivalent to 2.8%, considering that the average level of physicians in this group (All) one year before the program was 2.08. When analyzing only the treated group, we observe a greater increase: 13.6% or 0.127 doctors per thousand inhabitants. On the other hand, in the estimation that considers the pseudo-placebo group, the coefficient, although positive, is not statistically significant. For health equipments, all coefficients were also positive, but not significant.

These evidences indicate that the pseudo-placebo group does not appear to have experienced a statistically significant change in physician coverage in the post-PMM period. This is an important result for the proposed analysis, since it shows that they did not present a net increase in the number of physicians. Thus, even being beneficiaries, these cities may not have seen improvement in health indicators because of the potential effects of the provision of doctors in PMM. Finally, the results for health equipments may suggest that the program has effectively focused on increasing the number of physicians, with less significant participation in the expansion of health infrastructure supply.

In order to analyze the results on ACSH for the entire group of municipalities that received PMM's doctors, we estimated a regression that does not discriminate the municipalities according to the variation in the scale of physicians due to the program. This estimation is presented in Table 3. In none of the three specifications the coefficients related to the program were statistically significant. By this result, PMM would have no impact. A second exercise involved the estimation considering only the pseudo-placebo group. The coeffcients were not significant, suggesting that the lack of

[12] Formally, the estimated equation is: $Y_{it} = \gamma + \beta(Post\ PMM_{it} \times PMM_i) + \theta_i + \varphi_t + \alpha_s \times t + \varepsilon_{it}$, where Y_{it} represents the number of physicians (or health equipments) per thousand inhabitants for municipality i and year t, Post PMM_{it} is a dummy variable for the period after the intervention, PMM_i is a dummy that indicates whether the municipality joined PMM, θ_i represents municipality fixed effects, φ_t represents year fixed effects, $\alpha_s \times t$ is a state-specific linear time trend and ε_{it} is an error term. The coefficient of interest is β.

significance in the previous estimation is associated with the group of cities that participated in PMM, but did not have a significant change in the physicians' supply. This evidence is also consistent with the lack of significance of the coefficient that captures the effects of PMM on the number of physicians for the pseudo-placebo group (Table 2). In view of these findings, we present from now on the analysis considering the proposed identification strategy.

Table 3: Impact of PMM (DDM_i) on ACSH for all municipalities that received program's doctors and for the placebo group

	All		Pseudo-Placebo	
	(1)	*(2)*	*(1)*	*(2)*
Post PMM	-0.238 (0.235)	-	0.166 (0.263)	-
PMM 3 years before	-	(omitted)	-	(omitted)
PMM 2 years before	-	-0.394 (0.310)	-	-0.031 (0.209)
PMM 1 year before	-	0.056 (0.330)	-	0.124 (0.284)
PMM year 1	-	0.040 (0.445)	-	0.311 (0.322)
PMM year 2	-	-0.194 (0.450)	-	0.098 (0.367)
PMM year 3	-	-0.257 (0.417)	-	0.127 (0.460)
Observations	29,112	29,112	22,350	22,350
Adjusted R^2	0.81	0.82	0.91	0.91

Note: Significant to 1% (**) and 5% (*). Regressions include municipality fixed effects and state-specific linear time trends. Bootstrapped standard errors (500 replications) in parentheses clustered at the municipality level.

Figure 1 depicts the distribution of treatment probability for treated and control groups. The municipalities in the treatment group were quite distinct from the municipalities in the control group in observable characteristics. After matching, the distribution of the estimated probability became very similar between the groups. Table A.1 in the Appendix shows that there are no significant differences in covariate means for both groups after matching (with the exception of variable 'Schools'), which mitigates possible selection biases[13].

[13] In Table A.1 it is still possible to verify what happened to Pseudo R^2 of the Logit model after matching. As can be seen, the pseudo R^2 decreases from 0.23 to 0.01 when the sample is matched, which indicates that the explanatory power of the covariates falls becasue they can no longer explain the differences between the groups and also the probability of participating in the program. Finally, the mean and median biases also present a significant reduction.

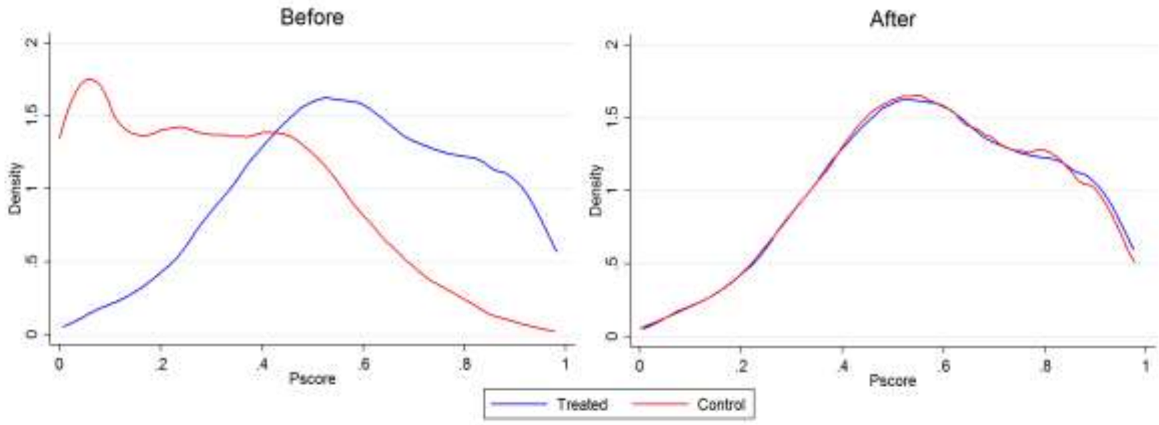

Figure 1 – Distribution of the probability of treatment for treated and controls - Before and after matching

Table 4 shows the impacts of PMM in the treated municipalities that received doctors during the first year of the program. The specification (1) indicates that, after the intervention, there was a relative drop in the treated cities of 0.953 hospitalization for ambulatory care sensitive conditions per thousand inhabitants.

The specification (2) considers the DDM_i estimator for each year between 2010 and 2016. It is noted that the estimated coefficient for the first year of the program is not statistically significant. Although, the coefficient for the second year indicates a relative drop of 6% (0.697 in absolute terms) on ACSH among the treated - considering the average hospitalization level of this group one year before the program (11.7). In the following year, this impact is even greater: 13.6% (1.421 in absolute terms) less hospitalizations among the beneficiary cities.

Table 4: Impact of PMM (DDM_i) on ACSH for the treated municipalities that received doctors from the PMM program in year 1 (Aug/2013 –Jul/2014)

	(1)	*(2)*
Post PMM	-0.953** (0.195)	-
PMM 3 years before	-	(omitted)
PMM 2 years before	-	-0.303 (0.200)
PMM 1 year before	-	-0.272 (0.258)
PMM year 1	-	-0.519 (0.255)
PMM year 2	-	-0.697* (0.273)
PMM year 3	-	-1.421** (0.322)
Observations	16,950	16,950
Adjusted R^2	0.86	0.86

Note: Significant to 1% (**) and 5% (*). Regressions include municipality fixed effects and state-specific linear time trends. Bootstrapped standard errors (500 replications) in parentheses clustered at the municipality level.

As presented in Section 2, the adhesion of municipalities in PMM can be thought of in two large expansion cycles: between August 2013 and December 2013 and between January 2014 and July 2014. Considering these, we separated the treated municipalities into two groups: those who received physicians linked to the program in 2013 and those who received them in the first half of 2014. Table 5 presents the causal impact of PMM for each of them. The DDM_i estimator for the first year of the program is still not statistically significant. However, the coefficient of (1) is higher for the group of municipalities that received doctors linked to PMM in 2013. For this group, the relative drop on avoidable hospitalizations was 9.4% (1.110 in absolute terms) against 6.4% (0.753 in absolute terms) for the cities that received physicians in 2014. These results indicate that the cities who had a longer time of exposure to PMM presented a greater reduction in hospitalizations than those cities that joined PMM later.

From the second year on, the effects of PMM turn out to be perceptible. For the first group, there was a reduction of 6.4% (0.755 in absolute terms) on ACSH in the 'PMM year 2' and of 12.8% (1.53 in absolute terms) in the 'PMM year 3'. For the second group, the relative reduction on avoidable hospitalizations were 6% (0.717 in absolute terms) and 11.4% (1.342 in absolute terms), respectively.

Table 5: Impact of PMM (DDM_i) on ACSH for the treated municipalities that received doctors from the PMM program in two distinct periods of the program

	Aug/2013 – Dec/2013		Jan/2014 – Jul/2014	
	(1)	*(2)*	*(1)*	*(2)*
Post PMM	-1.110** (0.276)	-	-0.753** (0.271)	-
PMM 3 years before	-	(omitted)	-	(omitted)
PMM 2 years before	-	-0.304 (0.198)	-	-0.045 (0.246)
PMM 1 year before	-	-0.250 (0.289)	-	-0.079 (0.312)
PMM year 1	-	-0.667 (0.405)	-	-0.219 (0.321)
PMM year 2	-	-0.755* (0.321)	-	-0.717* (0.356)
PMM year 3	-	-1.530** (0.458)	-	-1.342** (0.377)
Observations	15,048	15,048	11,988	11,988
Adjusted R^2	0.86	0.87	0.87	0.88

Note: Significant to 1% (**) and 5% (*). Regressions include municipality fixed effects and state-specific linear time trends. Bootstrapped standard errors (500 replications) in parentheses clustered at the municipality level.

6 Robustness Analysis

In the specifications (2) of Tables 4 and 5, the DDM_i coefficients for the three periods before the program were also estimated. The parameters were not statistically significant, which indicates, on average, that before intervention the trend of ACSH was similar for both groups. To complement the analysis, we present in Figure B.1 of the Appendix the evolution of the outcome variable over time in treated and untreated matched municipalities. The figure corroborates the parallel trend assumption of the difference-in-difference approach. These strategies served as a robustness test to confirm that the results are capturing the effect of the More Doctors Program on hospitalizations and not other shocks that could differentiate the treatment and control groups over time, since the outcome variable only differentiated between the groups after the intervention started.

Estimations presented in Table 3 considering the pseudo-placebo group also served as a falsification test. As suggested by Imbens (2004), to assess whether treatment evaluations are not spurious, a common practice in the literature of causal inference is to estimate the results using as placebo of the treated group, one that would not suffer the intervention effects. Table 2 showed that the pseudo-placebo group, although beneficiary of the program, did not experience a statistically significant increase in the number of physicians due to PMM. So the pseudo-placebo seems to be an appropriate group for this test and our evidence does indicate no effects of the policy on ACSH for these cities.

Finally, Table B.3 presents the determinants of municipalities' participation in the program in order to test the hypothesis of dynamic endogeneity between ACSH and the variable referring to PMM. The ACSH coefficients both at the level of the year preceding the program and at the variation of the previous three years are not significant, indicating that there is no correlation between adhesion in the program and the contemporary and dynamic behavior of the dependent variable.

7 Discussions and Conclusion

The results found in this article indicate that PMM had an impact on the reduction of hospitalizations for ambulatory care sensitive conditions in Brazilian municipalities in need of public health care. From the coefficients in Table 4 for the third year of the program (-1.4) we can analyze the approximate gross reduction in the number of hospitalizations. Considering that the treated municipalities had, on average, 13,000 inhabitants, it is estimated that after three years of program, PMM contributed to a decrease of 23,148[14] hospitalizations. In monetary terms, it is equivalent to an economy of US$ 6,185,019.85, considering the average cost of hospitalizations referring to the diseases contained in the outcome variable proposed in this study for the municipalities of the treatment group[15,16].

The results obtained are in line with other studies in existing literature on this subject that point to an inverse relationship between the supply of physicians and hospitalization for ambulatory care sensitive conditions (Parchman & Culler 1994; Basu, Friedman, & Burstin 2002; Laditka, Laditka & Probst 2005; Ansari, Laditka & Laditka 2006). In Brazil the magnitude of this relationship is noteworthy since for the treated cities there was a drop on admissions in the second year of the program,

[14] A total of 1,286 treated municipalities remaining after the matching required for double difference matching were used. The exercise consisted of the following operation: $\frac{13{,}000}{1{,}000} \times 1.4 \times 1{,}286$.

[15] Information obtained from DATASUS. The average cost of hospitalizations for August 2016, equivalent to US$ 267.19, was considered.

[16] A more accurate cost-benefit analysis is not possible since we do not have information about program's costs and for other program components major results are expected only in a longer term.

suggesting that the provision of doctors has a fairly rapid effect on this variable. Santos et al. (2017), albeit using a distinct strategy to identify the treated municipalities, also found that avoidable hospitalizations dropped after PMM.

In terms of public policy effectiveness, the results presented are even more relevant considering that the ACSH variable is also understood as an indicator of accessibility and overall effectiveness of a country's basic health care (Institute of Medicine 1993; Bindman *et al.* 1995; Starfield, Shi, & Macinko 2005; Ansari, Laditka, & Laditka 2006; Brazilian Ministry of Health 2008). In this sense, the More Doctors Program seems to be fundamental for the strengthening of primary health care in Brazil, especially considering another result found here: the increasing effect of the program over its three years – a result consistent with Rocha & Soares (2010) in the evaluation of another Brazilian health public policy, the Family Health Program[17].

Regarding the impacts of PMM, it is expected that in the short term they are driven mainly by a reduction of acute diseases. Nevertheless, as pointed out by Macinko, Dourado & Guanais (2011), primary care plays a fundamental role in the prevention of chronic diseases. In this way, PMM is also important for controlling this type of disease. Table A.3 summarizes the main actions taken in primary care for this purpose. As can be seen, most of them are preventive actions as diet and physical activity counseling, blood pressure control, blood glucose monitoring, etc. Since preventive medical care demands time, more sizeable effects on chronic diseases are expected in a longer term.

Some other potential mechanisms for the results are described by Laditka (2004). According to the author, asthma, diabetes, lung and heart disease exemplify some of the chronic diseases whose hospitalization can be prevented, in part, by simple drug prescription or patient education by a primary care physician. Other acute illnesses, such as pneumonia and urinary tract and kidney infections, can also be prevented without the need of hospitalization by the prescription of antibiotics from a medical professional.

The results found in this article also point to the need for a more in-depth discussion on targeting physicians in poorer regions. As already highlighted, the PMM was conceived with the objective of correcting regional inequalities in the distribution of doctors in Brazilian national territory. As a positive point, it should be emphasized that cities that had a significant change of scale in physicians' supply due to PMM were precisely those disadvantaged in terms of socioeconomic and public health characteristics. However, there are a greater number of cities receiving physicians from program which do not fit these characteristics. Considering these, the Ministry of Health could revise the design of the program regarding its selection criteria.

Corroborating this discussion, the causal estimates obtained in this study pointed to a positive effect of PMM only in treated municipalities, while effects in the pseudo-placebo municipalities were not found. Thus, these results suggest that the global debate about physicians' provision policies should be guided by the reduction of inequalities in the geographical distribution of these professionals (Goodman 2004; Luo, Wang, & Douglass 2004; Matsumoto et al. 2010; Ono, Schoenstein, & Buchan 2014).

Finally, the contribution of this study is to present evidence that can go beyond the evaluation of the More Doctors Program. The results indicated that in Brazil the provision and reallocation of physicians could positively impact the performance of the basic health system, contributing to the formulation of related public policies around the

[17] In the eight-year evaluation of this program, the authors found persistent effects, suggesting that actions in pri-mary care tend to produce permanent results over time. The same is expected of PMM, mainly due to the similarity in relation to the preventive nature of the physicians' scope of practice.

world.

Although it is not the focus of this paper to evaluate the other pillars of actions of PMM, a discussion of their potential benefits is important for a more comprehensive analysis about the program. As a long-term policy, PMM aims to invest about US$ 1.3 billion in the reform and construction of health basic units. Even though this intervention may enhance the effects of the physicians' provision, so far there is no information on the results of this component as a whole.

In relation to the number of medical graduates, the goal of PMM was to open 11,500 new seats in medical schools by 2017. Data from the Brazilian Ministry of Health show, however, that this goal was not reached as only 8,100 new seats were created in the same period. It should be considered that this component can contribute to mitigate doctor shortage in a more remote period (7 to 10 years) and therefore is complementary to the recruitment of professionals trained abroad to serve through the program in the short term (Moullan & Chojnicki 2017).

This measure was necessary because before PMM started the Brazilian medical training had not been focusing on primary care and also because the working conditions had not been stimulating Brazilian doctors to work in poorer regions. The turnover of physicians in BHU was a recurrent problem in the municipalities, either due to problems in their infrastructure or to unattractive remuneration.

In this sense, another relevant modification induced by the program seeks to change this figure: the restructuring of the medical curriculum in Brazil for both new and existing medical schools. The bulk of the change is a greater focus of teaching on primary care, reflected in mandatory completion of a two-year period of practice in BHU by medical students during graduation and also in completion of one-year specialization course in Family Medicine during medical residency. All these measures aim to improve PMM results on basic health care in the long term and can be explored in future research in order to provide a broader evaluation of the program.

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Appendix A – Data

The outcome variable, hospitalizations for conditions sensitive to primary care, was obtained from the Department of Information Technology of UHS (DATASUS) based on the diseases contained in Ordinance nº. 221 of 2008 of the Ministry of Health. Other public health variables (doctors, health care establishments, health professionals and health facilities) as well as sanitation (percentage of households registered in Primary Care with electricity, open garbage and without water treatment) were also obtained from DATASUS. The number of public schools in the municipalities was obtained from the National Institute of Studies and Educational Research Anísio Teixeira (INEP), the per capita Gross Domestic Product (GDP) and transfers from the *Bolsa Família* Program (PBF) per capita from the Institute of Applied Economic Research (IPEA), and the average salary and occupancy rate from the Annual Report on Social Information (RAIS) of the Ministry of Labor. The data referring to the number of PMM physicians in each municipality were obtained through a request for access to information to the Ministry of Health (Brazilian Access to Information Law, No. 12.527/2011).

Table A.1 - Description of variables

Variable	Period	Description
ACSH	2010-2016	Hospitalization for conditions sensitive to primary care per 1,000 inhabiants by place of residence.[18]
Open Garbage	2010-2016	Percentage of households registered in Primary Care with open garbage.
Energy	2010-2016	Percentage of households enrolled in Primary Care with electric energy.
Untreated Water	2010-2016	Percentage of households enrolled in Primary Care with treated water.
Health Professionals	2010-2016	Number of health professionals, except physicians, per 1,000 inhabitants.
Health Equipments	2010-2016	Number of health equipments per 1,000 inhabitants.
Physicians	2010-2016	Number of physicians, except veterinarian, per 1,000 inhabitants - disregarding physicians linked to PMM.
Beds	2010-2016	Number of beds per 1,000 inhabitants.
Health Facilities	2010-2016	Number of health facilities per 1,000 inhabitants.
Schools	2010-2016	Number of public schools per 1,000 inhabitants.
Occupancy rate	2012	Percentage of employees over the total population.
Average Wages	2012	Value of the average remuneration, measured in minimum salaries, referring to the month of December.
GDP *per capita*	2012	Natural logarithm of the Gross Domestic Product (GDP) per capita.
PBF *per capita*	2012	Natural logarithm of per capita transfers from the *Bolsa Família* Program*.
Dummies UF	2012	Binary variables for the 27 Brazilian states.

Note: (*) The *Bolsa Família* Program is the main Brazilian income transfer program for populations living in poverty and extreme poverty.

Table A.2: Regional distribution of municipalities for treated, pseudo-placebo and control groups

Region	Treated		Pseudo-Placebo		Control		Total
	No. (A)	% (A)/(D)	No. (B)	% (B)/(D)	No. (C)	% (C)/(D)	No. (D)
North	235	53.29	105	23.81	101	22.90	441
Northeast	547	32.25	666	39.27	483	28.48	1696
Central-West	100	23.36	170	39.72	158	36.92	428
South	228	19.91	572	49.96	345	30.13	1145
Southeast	212	13.60	655	42.01	692	44.39	1559

[18] Iron deficiency anemia, Mellitus Diabetes, Malnutrition, Vitamin A deficiency, Other vitamin deficiencies, Sequelae of malnutrition and other nutritional deficiencies, Volume depletion, Epilepsy, Average Otitis and other disorders in middle ear and mastoid, Acute rheumatic fever, Other acute hypertension, Primary hypertension, Other hypertensive diseases, Heart failure, Other heart diseases, Acute pharyngitis and acute tonsillitis, Other acute upper respiratory infections, Pneumonia, Acute bronchitis and acute bronchiolitis, Asthma, Skin infections, Other diseases of the skin and subcutaneous tissue, Cystitis, Other diseases of the urinary tract, Salpingitis and oophoritis, Inflammatory disease of the cervix, Other inflammatory diseases of the female pelvic organs.

Table A.3: Chronic diseases and main actions taken in primary care for their treatment

Noncommunicable chronic disease	Main actions
Avoidable Cancers (breast, cervical, cervix, prostate, lungs)	Periodic examinations, smoking cessation techniques, diet and physical activity counseling
Diabetes	Blood glucose monitoring, medications to lower glucose, control of cardiovascular risk factors
Hypertension	Blood pressure control, prescription and adherence to antihypertensive drugs, smoking cessation techniques, diet and physical activity counseling
Other cardiovascular diseases	Blood pressure control, prescription and adherence to antihypertensive and lipid-lowering drugs, smoking cessation techniques, diet and physical activity counseling
Cerebrovascular disease (stroke)	Monitoring of blood pressure, prescription and adherence to medicines, smoking cessation techniques, diet and physical activity counseling, post-stroke rehabilitation.
Asthma	Asthma control and monitoring of inhaler use
Chronic obstructive pulmonary disease	Smoking cessation techniques, coordination of diagnostics and medicines

Source: adapted from Macinko, Dourado & Guanais (2011).

Appendix B – Robustness

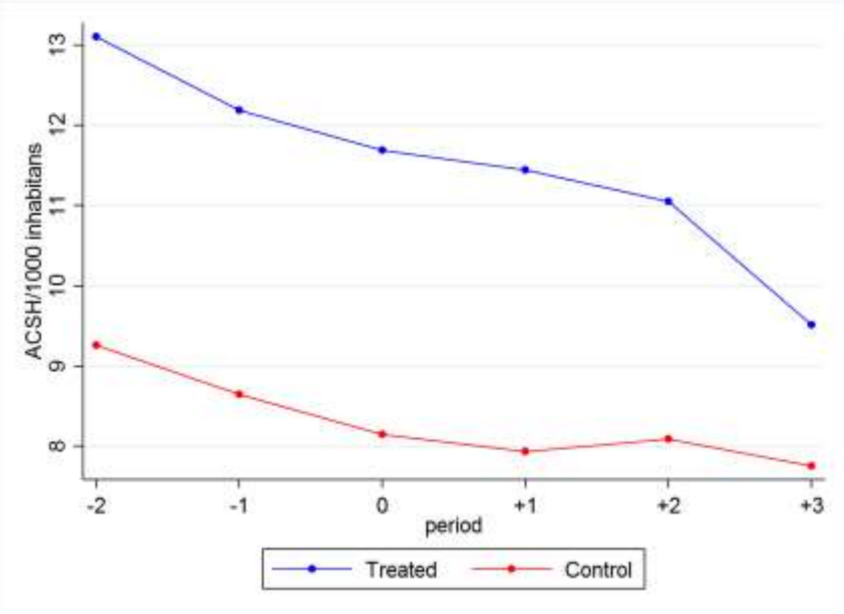
Table B.1: Test for equality of means for treated and control groups before and after mathcing

Variables	Before Matching			After Matching		
	Trataded	Control	p>|t|	Trataded	Control	p>|t|
Population	12,923	12,149	0.356	12,567	12,468	0.901
Schools	3.201	2.596	0.000	3.193	3.350	0.042
Open Garbage	0.157	0.088	0.000	0.157	0.156	0.789
Energy	0.903	0.956	0.000	0.905	0.903	0.651
Untreated Water	0.338	0.347	0.432	0.341	0.337	0.717
Physicians	0.925	1.876	0.000	0.933	0.963	0.202
Beds	0.900	1.497	0.000	0.895	0.873	0.670
Health Facilities	0.869	1.170	0.000	0.877	0.895	0.327
Health Professionals	2.883	4.055	0.000	2.902	2.977	0.187
Health Equipments	0.170	0.297	0.000	0.170	0.171	0.947
Average Wages	1.824	1.911	0.000	1.821	1.809	0.506
Occupancy rate	0.123	0.212	0.000	0.122	0.101	0.451
PBF per capita	3.200	2.708	0.000	3.193	3.164	0.306
GDP per capita	9.295	9.467	0.000	9.296	9.290	0.842
Dummy UF1	0.016	0.022	0.213	0.016	0.015	0.819
Dummy UF2	0.038	0.001	0.000	0.026	0.024	0.721
Dummy UF3	0.009	0.001	0.001	0.008	0.011	0.422
Dummy UF4	0.109	0.029	0.000	0.111	0.091	0.097
Dummy UF5	0.052	0.010	0.000	0.053	0.057	0.615
Dummy UF6	0.005	0.013	0.019	0.005	0.005	0.934
Dummy UF7	0.030	0.042	0.074	0.030	0.032	0.837
Dummy UF8	0.068	0.032	0.000	0.069	0.070	0.963
Dummy UF9	0.118	0.227	0.000	0.120	0.113	0.584
Dummy UF10	0.012	0.011	0.792	0.012	0.011	0.896
Dummy UF11	0.025	0.027	0.770	0.025	0.025	0.944
Dummy UF12	0.054	0.010	0.000	0.055	0.045	0.270
Dummy UF13	0.043	0.057	0.098	0.044	0.046	0.798
Dummy UF14	0.024	0.021	0.531	0.025	0.019	0.371
Dummy UF15	0.074	0.058	0.080	0.076	0.079	0.738
Dummy UF16	0.056	0.058	0.750	0.057	0.055	0.900
Dummy UF17	0.025	0.045	0.005	0.025	0.037	0.085
Dummy UF18	0.025	0.001	0.000	0.022	0.022	0.940
Dummy UF19	0.071	0.081	0.326	0.072	0.084	0.269
Dummy UF20	0.048	0.055	0.357	0.049	0.050	0.852
Dummy UF21	0.017	0.014	0.523	0.018	0.017	0.852
Dummy UF22	0.034	0.139	0.000	0.035	0.036	0.945
Dummy UF23	0.035	0.046	0.151	0.036	0.035	0.889
Dummy UF24	0.013	0.002	0.000	0.013	0.020	0.146

Sample	Pseudo R^2	p>chi2	Mean bias	Median Bias
Non-matched	0.23	0.000	22.7	17.4
Matched	0.01	0.940	2.2	1.3

Nota: p>|t| refers to the p-value of the t-test of equality of means for the groups. p>chi2 refers to the p-value of the likelihood-ratio test.

Figure B.1: Yearly ACSH for treated and weighted control groups



Note: the periods refer to years before and after PMM, with period zero refering to 'PMM 1 year before' of Tables 3, 4 and 5.

Table B.3: Logit estimation of the probability of joining the program, PMM year 1

Time-varying covariates		*Variables measured in 'PMM 1 year before'*	
Δ ACSH	-0.001	ACSH	-0.005
	(0.19)		(0.94)
Δ Open Garbage	0.743	Open Garbage	0.465
	(0.48)		(0.91)
Δ Energy	-1.477	Energy	-1.115
	(0.81)		(1.67)
Δ Untreated Water	-0.055	Untreated Water	-0.129
	(0.07)		(0.55)
Δ Health Professionals	0.125	Health Professionals	-0.029
	(1.86)		(0.69)
Δ Health Equipments	0.126	Health Equipments	0.295
	(0.21)		(1.49)
Δ Physicians	-0.101	Physicians	-0.996**
	(0.70)		(9.75)
Δ Beds	-0.077	Beds	-0.077*
	(0.13)		(2.33)
Δ Health Facilities	-0.301	Health Facilities	-0.187
	(1.20)		(1.44)
Δ Schools	0.019	Schools	0.024
	(0.60)		(0.74)
		Occupancy rate	-0.000
			(1.75)
		Average Wages	-0.008
			(0.70)
		GDP *per capita*	0.093
			(1.03)
		PBF *per capita*	0.399**
			(3.83)
Observations		2,913	
Pseudo R^2		0.23	

Note: Significant at 1% (**) and 5% (*). Dummies were included for states. Variations considered cover 'PMM 3 years before' until 'PMM 1 year before'. In parentheses, z statistic.