The effect of primary care physician on hospitalization for ambulatory care sensitive conditions among children in Brazil

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ABSTRACT

Hospitalizations for Ambulatory Care Sensitive Conditions (ACSH) are health conditions for which hospitalization can be avoided if primary care is provided in a timely and effective manner. ACSH account for more than half of all hospital admissions among children under five years old in Brazil. The objective of the study is to investigate the effects of primary care physicians (PCPs) on hospitalization for ambulatory care sensitive conditions among children under five years old in Brazilian municipalities. Spatial dynamic panel data model was estimated using municipality data over a period of eight years from 2005 to 2012. The regression includes two spatial variables, hospital beds and PCPs, which allow spatial interactions between neighboring units. The results indicate that primary care physician supply contributed to the decline of ACSH among children. Spillover effects associated with hospital beds and number of PCPs are relevant in explaining ACSH among children. These show that there are regional benefits beyond the municipality of observation.

Keywords: Brazil; Primary care physicians; Child health; Ambulatory care sensitive conditions; Dynamic panel data; Spatial effects.

RESUMO

Internações por Condições Sensíveis à Atenção Primária (ICSAP) são doenças e agravos de saúde cuja hospitalização são potencialmente evitáveis diante de um nível de atenção básico efetivo e oportuno. No Brasil, as ICSAP correspondem por mais da metade de todas as internações hospitalares entre crianças menores de cincos anos. Nesse sentido, o presente estudo tem como objetivo analisar o efeito do aumento no número dos médicos da atenção básica na taxa de hospitalização por condições sensíveis à atenção primária entre crianças menores de cinco anos nos municípios brasileiros. Para tanto, foi estimado um modelo de dados em painel dinâmico espacial para o período de 2005-2012. Duas variáveis espaciais foram incluídas, número de médicos da atenção básica e leitos hospitalares. Os resultados indicam que o aumento do número de médicos da atenção básica contribuiu para a redução das ICSAP entre crianças. Além disso, as variáveis espaciais também foram significantes para explicar as ICSAP, indicando a existência de benefícios regionais além do município de observação.

Palavras-chave: Brasil; Médicos da atenção básica; Saúde da criança; Condições sensíveis à atenção primária; Painel dinâmico espacial; Efeitos espaciais.

CLASSIFICAÇÃO JEL: I14; I18; C33

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1 INTRODUCTION

The patterns of hospitalizations provide useful information to determine health problems related to primary care (CASANOVA et al., 1996). In recent decades, hospitalization for ambulatory care sensitive conditions (ACSH) has been extensively used as an indicator to evaluate the accessibility and effectiveness in the delivery of primary care (ANSARI et al., 2006). This indicator, also called potentially preventable hospitalization, is based on the knowledge that adequate care might reduce the occurrence of disease and consequently decrease the need for hospital admission. The term of ambulatory care sensitive (ACS) conditions was developed by Billings et al. (1993) to denote health conditions for which hospitalization can be avoided if primary care is provided in a timely and effective manner. The lower risk of hospitalization is related to prevention, control and management of the disease or condition.

There are two empirical approaches using ACSH indicator (ANSARI et al., 2006). First, the relationship between ACSH and access to health care is analysed by the effects of physician supply. This approach has as assumption that access is positively associated with supply. The second examines the relationship between ACSH and self-rated access to health care. Both approaches has been empirically confirmed.

In recent years, evidence of the physician supply on ACSH rate has been accumulating in diverse groups, such as among adults (LIN et al., 2016; RIZZA et al., 2007; ROSANO et al., 2016), children (FRIEDMAN; BASU, 2001; GUTTMANN et al., 2010) and by specific disease (WALKER et al., 2014). Laditka *et al*. (2005) evaluated the effects of PCP on ACSH rates for children, younger adults and middle adults. They found the number of physicians associated with lower ACSH in all age groups, with largest contributor of PCP to ACHS among children.

In Brazil, children’s health has received priority attention (PEDRAZA; ARAUJO, 2017). Some of the preventable diseases, such as acute disease, occur predominantly during the early years of life (CARVALHO et al., 2015; MOURA et al., 2010; PAZÓ et al., 2012). In addition to other avoidable comorbidities, they represent a high proportion of hospitalization and mortality among children under five years old. In 2012, ACSHs accounted for around half of all hospital admissions among children under five years old in Brazil (DATASUS, 2017). Children were predominantly admitted for pneumonia, intestinal infections (other), gastroenteritis and colitis of infectious origin, asthma, and acute bronchitis and acute bronchiolitis.

In view of the high ACSH rates in Brazil, the Ministry of Health elaborated the Brazilian list of hospitalization due to primary care sensitive conditions in 2008 (ALFRADIQUE et al., 2009; MINISTRY OF HEALTH, 2008). Since then several studies have emerged on this topic. In general, these studies have analysed the time trend and causes of ACSH. There are few studies using longitudinal data, especially for ACSH among children. We identified two studies that evaluated the effect of primary care on ACHS among children in Brazil. The first one restricts the analysis to one Brazilian state, Pernambuco State (CARVALHO et al., 2015). Second study assess a specific disease, pneumonia (PAMPONET, 2014). Both studies use a negative binomial model and show the effective of primary care in reducing hospitalization rate. However, these studies don’t evaluate the effect of overall PCP on ACSH.

In order to evaluate the effect of increasing PCP on ACSH rates among children under five years old in Brazilian municipalities, we use a robust approach, spatial dynamic panel data model, for a period of eight years from 2005 to 2012. Dynamic panel data model accounts for endogeneity and unobserved municipality-specific effects, furthermore, it improves the accuracy of estimates when the dependent variable is persistent over time. The model also includes two spatial variables, hospital beds and PCPs, which allow spatial interactions between neighboring units. These variables identify the spatial spillovers effects of hospital beds and PCPs on municipal hospitalization rate.

2 DATA AND METHOD

2.1 Data

The study follows a balanced panel of 3,846 municipalities in Brazil over a period of 8 years from 2005 to 2012. The study focuses on hospital admission, therefore, only municipalities with hospital beds are included in the main analysis. ACSH rate is defined as the number of hospitalization for ambulatory care sensitive conditions under five years old per 1,000 population under five years old. The definition of ambulatory care condition follows the Ordinance SAS/MS No. 221, of April 17, 2008. Based on the International Classification of Diseases (ICD-10), the Ministry of Health elaborated the Brazilian list for ambulatory care sensitive hospitalizations. This list was created, after extensive discussion, as a tool for measuring the Brazilian health system performance. Table A1, in Appendix, reports the Brazilian list for ambulatory care sensitive hospitalizations and the codes used.

In addition the density of primary care physician, defined as the total number of PCPs per 10,000 population, a set of variables known to be associated with child health was included in the analyses as covariates: other FHS team per 10,000 population, hospital beds per 10,000 population, percentage of female illiteracy, Gross Domestic Product (GDP) per capita, area density, percentage of household with sewage and percentage of household with trash collection.

The data are mainly taken from the Brazilian Ministry of Health (DATASUS – Department of the SUS). Primary care physician and other FHS team are collected using TabWin – program developed by DATASUS/Ministry of Health. Primary care physician, other FHS team and hospital beds are from National Registry of Health Facilities (CNES).

Hospitalization for ambulatory care sensitive conditions is obtained from the Hospital Information System of the Unified Health System (SIH/SUS). Data on GDP, area and population are obtained from the Brazilian Institute of Geography and Statistics (IBGE). Data on trash collection and sewage are taken from National Census Bureau. The data on female illiteracy is based on the Annual List of Social Information (RAIS) from the Ministry for Labor and Employment (MTE); this data is only available for female workers in the formal sector.

Annual values for all variables are available from the database, except for household facilities. Linear interpolation is used to estimate annual values of trash collection and sewage for the period 2005 to 2009. The estimates are based on the National Census for 2000 and 2010. For the posterior period, 2011 and 2012, linear extrapolation is used based on the same function.

In this paper, primary care physicians are measured using the sum of the hours worked per week of FHS physicians, community physicians, general practitioners (GPs), general pediatricians and gynecologists/obstetricians who work in healthcare centers (healthcare centers include *Centro de Saúde/Unidade Básica de Saúde, Posto de Saúde* and *Centro de Apoio a Saúde da Família – CASF*). Healthcare centers are designed to provide primary health care to the population and they concentrate primary health teams. Physicians working in hospitals are not included. The total number of PCPs is calculate dividing the total hours worked per week by 40. The professionals work, in general, 40 hours per week. This measure allows more accuracy to compare the availability of physicians among municipalities, since the physicians may present diverse workload in Brazil.

Other FHS team include nurses and nurses assistant. Nurses of FHS are included as covariate based on their relevant role for primary care and infant health (SANTOS; MIRANDA, 2007; SAPAROLLI; ADAMI, 2007). The total number of other FHS team is calculate dividing the total hours worked per week by 40.

2.2 Descriptive statistics

Table 1 shows the descriptive statistics of each variable over the whole period.

Table 1 - Descriptive statistics for Brazilian municipalities

	Obs	Mean	Std. Dev.	Min	Max
ACSH per 10000 pop. < 5 years old	30768	57.25	43.22	0	483.47
PCP per 10000 pop.	30768	2.95	1.51	0	20.99
Other FHS team per 10000 pop.	30768	6.12	3.52	0	34.17
Hospital beds per 10000 pop.	30768	27.35	22.47	0	404.26
Lag Hospital beds per 10000 pop.	30768	19.53	9.62	0	102.33
Lag PCP per 10000 pop.	30768	3.35	1.22	0	12.12
GDPpc	30768	13581.06	15864.36	1835.86	336836.10
Female illiteracy (%)	30768	0.55	1.62	0	45.36
Area Density	30768	1141.66	3385.28	0.75	131646.80
Sewage (%)	30768	29.84	30.70	0	100.00
Trash Collection (%)	30768	68.62	22.41	0	100.00

Data from the 3,846 municipalities in the restricted sample

Table 2 reports the means of the variables for each time period. The ACSH rate decreased 23.3% over period. The number of primary care physicians per 10,000 population increased from 2.5 in 2005 to 3.2 in 2012. Percentage of household with sewage, with trash collection and female education an improvement over the entire period.

Table 2 – Variable means for Brazilian municipalities, by year (2005-2012)

	2005	2006	2007	2008	2009	2010	2011	2012
ACSH per 10000 pop. < 5 years old	62.23	60.43	60.78	54.78	55.98	63.56	52.56	47.70
PCP per 10000 pop.	2.54	2.50	2.88	3.02	3.09	3.18	3.17	3.22
Other FHS team per 10000 pop.	4.43	4.69	5.74	6.20	6.57	6.87	7.08	7.37
Hospital beds per 10000 pop.	29.52	29.21	28.79	26.96	26.62	26.44	25.92	25.30
Lag Hospital beds per 10000 pop.	21.12	20.88	20.61	19.26	19.04	18.88	18.48	18.00
Lag PCP per 10000 pop.	2.95	2.90	3.28	3.42	3.49	3.59	3.56	3.62
GDPpc	11613.8	12178.0	12616.1	13105.2	14074.6	14590.9	15382.1	15088.0
Female illiteracy (%)	0.86	0.76	0.67	0.62	0.55	0.50	0.23	0.21
Area Density	1203.9	1197.9	1165.1	1128.2	1123.5	1115.3	1106.7	1092.6
Sewage (%)	27.97	28.51	29.04	29.57	30.11	30.65	31.18	31.71
Trash Collection (%)	63.02	64.62	66.22	67.82	69.41	71.12	72.60	74.17

Data from the 3,846 municipalities in the restricted sample

ACSHs account for more than half of all hospital admission between children under 5 years old in Brazil. Children are predominantly admitted for pneumonia, gastroenteritis and colitis of infectious origin, intestinal infections (other), asthma, and acute bronchitis and acute bronchiolitis (Table 3).

Table 3 – Most frequent causes of ACSH among children

	2005	2006	2007	2008	2009	2010	2011	2012
Pneumonia	36.0%	37.2%	40.3%	39.6%	42.1%	39.1%	40.6%	39.0%
Other intestinal infections	14.8%	14.8%	11.6%	13.8%	12.2%	13.2%	10.2%	9.9%
Gastroenteritis and colitis of infectious origin	13.7%	14.1%	11.5%	12.0%	10.9%	12.5%	10.5%	11.6%
Asthma	13.4%	12.5%	14.0%	10.4%	9.8%	9.7%	9.8%	9.1%
Acute bronchitis and Acute bronchiolitis	3.1%	3.3%	4.2%	4.5%	4.9%	5.2%	6.8%	7.2%

Source: DATASUS, 2017

The Pearson correlation matrix shows that there is a highly positive correlation between PCP and Other FHS team, ranging between 0.68 and 0.73 in the period. This occurs because a large portion of the PCPs make up the FHS team. Percentage of household with sewage and with trash collection also indicate a high correlation (Table 4).

Table 4 - Pearson correlation matrix municipality level, 2005-2012

	PCP	Other FHS team	Area density	Hospital beds	Lag Hospital beds	Gdppc	Illiteracy	LagPCP	Sewage	Trash col.
PCP	1.00									
Other FHS team	0.69 to 0.73	1.00								
Area density	-0.07 to -0.02	-0.04 to 0.07	1.00							
Hospitalbeds	0.12 to 0.21	0.10 to 0.16	-0.06 to -0.04	1.00						
LagHospital Beds	0.09 to 0.15	0.07 to 0.12	-0.05 to -0.03	0.29 to 0.30	1.00					
Gdppc	-0.06 to 0.04	-0.13 to -0.01	-0.02 to 0.00	0.05 to 0.06	0.06 to 0.08	1.00				
Female Illiteracy	0.01 to 0.04	0.01 to 0.09	-0.02 to 0.03	-0.08 to -0.00	-0.08 to -0.02	-0.08 to 0.00	1.00			
LagPCP	0.29 to 0.34	0.21 to 0.32	-0.13 to -0.08	0.19 to 0.22	0.05 to 0.16	-0.08 to 0.08	0.00 to 0.03	1.00		
Sewage	-0.22 to -0.07	-0.31 to -0.15	-0.20 to -0.18	0.03 to 0.05	-0.07 to -0.05	0.20 to 0.23	-0.01 to 0.04	-0.04 to 0.08	1.00	
Trash col.	-0.16 to 0.08	-0.24 to -0.01	-0.21 to -0.19	0.15 to 0.18	0.12 to 0.14	0.35 to 0.38	-0.08 to 0.03	0.02 to 0.25	0.53 to 0.59	1.00

Data from the 3,846 municipalities in the restricted sample

2.3 Method

In this section, we describe the empirical approach to identify the effects of PCPs on ACSH rates among children under five years old. We estimated a dynamic equation, which can be written as:

$$ACSH_{it} = \delta ACSH_{it\text{-}1} + \gamma PCP_{\text{it}} + \beta' X_{it} + \lambda_t + \eta_i + \varepsilon_{it} \qquad (1)$$

The dynamic models can be estimated using Difference and System Generalized Method of Moments (GMM) estimators. Roodman (2009) compares both estimators and argues that System GMM is more appropriate for applications with persistent series - as our case. Therefore, we use the System GMM estimator for dynamic panel models developed by Arellano and Bover (1995) and Blundell and Bond (1998).

The literature demonstrates that the estimation of equation (1) using pooled OLS and fixed effect will potentially lead to biased and inconsistent results. According Nickell (1981), estimations using pooled OLS with lagged dependent variable violate the orthogonality condition. The assumption of OLS that the error is uncorrelated with the regressors is needed for the validity of estimates, which means the estimator may be inconsistent and biased. In other words, the correlation between η_{it} and $im_{it\text{-}1}$ or X_{it} is very likely not to be zero.

The fixed effects model treats the municipality specific effects producing unbiased and consistent estimators. However, the fixed effects estimator requires strict exogeneity and it is not hold in models with dynamic dependent variable (WOOLDRIDGE, 2001). As a result, the assumptions required for estimation of the model are also violated.

Difference and System Generalized Method of Moments (GMM) are estimators developed to dynamic panel models. There are popular for avoiding dynamic panel bias and handling with fixed effects and endogeneity of regressor (ROODMAN, 2009).

Initially, Arellano and Bond (1991) suggested the difference GMM estimator. This estimator includes the lagged levels of the explanatory variables as instruments and eliminates the fixed municipality specific effect by estimating the equation (1) in first differences

$$\Delta im_{it} = \delta \Delta im_{it\text{-}1} + \gamma \Delta PCP_{\text{it}} + \beta' \Delta X_{it} + \Delta \lambda_t + \Delta \varepsilon_{it} \qquad (2)$$

where $\Delta im_{it} = im_{it}$ - $im_{it\text{-}1}$. Since $\Delta im_{it\text{-}1}$ and $\Delta \varepsilon_{it}$ are correlated by definition, the OLS estimate is inconsistent. Later, Blundell and Bond (1998) showed that the GMM estimator obtained after first differencing is likely to perform poorly when the number of time periods is moderately small and the autoregressive parameter is moderately large. In such a case lagged levels of the series provide weak instruments for first differences. In order to address this problem, Blundell and Bond (1998) proposed the System GMM, a system of regressions in differences and levels, where the instruments used for the levels are lagged first-differences of the explanatory variables.

In order to allow spatial interactions between neighboring municipalities, the estimates include two spatial variables, hospital beds and number of PCPs. The spatial dynamic equation can be represented as:

$$ACSH_{it} = \delta ACSH_{it\text{-}1} + \gamma PCP_{\text{it}} + \beta' X_{it} + \varphi W.PCP_{it} + \omega W.HB_{it} + \lambda_t + \eta_i + \varepsilon_{it} \qquad (3)$$

where $ACSH_{it}$ is the hospitalization rates for ambulatory care sensitive conditions of municipality *i* at year *t*; $im_{it\text{-}1}$ denotes the lagged infant mortality rate and it is included to capture persistence in infant mortality; PCP_{it} is the density of primary care physicians; X_{it} contains a set of explanatory variables; HB_{it} is the density of hospital beds; *W* denotes the spatial weight matrix; λ_t indicate the unobserved time-specific effect controlling for common shocks to the infant mortality rate of all municipalities; η_i is the unobserved municipality-specific effect; and ε_{it} denotes the error term.

The System GMM estimator generates numerous instruments. There are two sorts of problems caused by the instrument proliferation (ROODMAN, 2009). First, the numbers of instruments can overtif the number of endogenous variables, just as known for applications using instrumental variable. The second problem refers the feasible efficient GMM, given that an optimal weighting matrix for the determining moments between instruments and errors is estimated using sample moments. As a result, the GMM estimator makes some asymptotic results and weakened specification tests. One way to deal with this problem is to collapse the instruments and limit the lag depth, as suggested by (ROODMAN, 2009). We follow this approach.

3 RESULTS

3.1 Dynamic panel model

Table 5 reports estimates for the effects of PCP on ACSH among children under five years old, equation (1), using OLS, random effects, fixed effects and System GMM. The regressions include a full set of variables known to be associated with child health, as well as year dummies. All estimations use robust standard errors.

The lagged dependent variable, hospitalization for ambulatory care sensitive conditions ($ACSH_{t-1}$), indicates a high degree of persistence in the ACSH among children over time, except after accounting for fixed effect which coefficient is small in magnitude. Column (1), (2) and (4) show that the coefficient on the number of PCPs is negative and statistically significant. It indicates that a rise in PCPs density leads to a decline in preventable hospitalization among children. Number of hospital beds is positively associated with hospitalization rate. The effects of other FHS team are not consistent over the four different estimation models, since the coefficients produce mixed evidence.

Table 5- Estimation results for ACSH among children using different estimation techniques

	OLS	Random Effects	Fixed Effects	System GMM
$ACSH_{t-1}$	0.816***	0.816***	0.343***	0.869***
	(0.00617)	(0.0061)	(0.0121)	(0.0137)
PC Physician	-0.340**	-0.340**	-0.013	-4.505***
	(0.155)	(0.138)	(0.267)	(1.696)
Other FHS team	-0.055	-0.055	0.135	2.017***
	(0.0672)	-0.062	(0.158)	(0.603)
Hospitalbeds	0.0671***	0.0671***	0.189***	0.168*
	(0.0077)	(0.0092)	(0.0362)	(0.0978)
Additional controls	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES
Observations	26,922	26,922	26,922	23,076
N of municipalities		3,846	3,846	3,846
Instruments				20
Hansen/Sargan test				0.21
AR1 test				-26.50***
AR3 test				4.74
F- test	1372.73***	23906.98***	151.50***	1021.74***

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Nickell (1981) pointed out that models estimated by OLS using panel data and including individual fixed effects produces asymptotic biases. In addition, Arellano and Bover (1995) and Blundell and Bond (1998) argue that, since lagged dependent variable exhibit a high degree of persistence, System GMM estimator is more appropriate. Thus, the following tables use GMM estimators.

The System GMM is consistent if the instruments are valid and there is no second order serial correlation. The validity of instruments is tested using the Hansen/Sargan test of over-identifying restrictions. The instruments are valid if the null hypothesis cannot be rejected. First-order, second-order and third-order serial correlation are tested using AR1, AR2 and AR3 statistics. The System GMM estimator is consistent if there is no significant AR(2) serial correlation of the residuals. If we cannot reject the serial correlation of order 2, deeper lags should be used. We use only lags starting at depth 3, since there is no evidence, at the 10% significance level, for no second-order serial correlation. As shown in table 6, all estimations present valid instrument and there is no evidence for significant AR(3) serial correlation of the residuals. Different specifications using System GMM are presented in order to test the sensitivity of the results to including additional controls.

The results show a negative and statistically significant effect of PCPs on ACSH among children. This finding is robust across all considered specification. The last column (column (6)) indicates that an increase of one PCP per 10,000 population is associated with 4.5 fewer children hospitalization per 1,000 population under five years old. All specifications of the model find a positive and statistically significant coefficient on other FHS team. In order to explore the relationship of theses variables, we estimated a new specification only including "other of FHS team" as independent variable (Table A1). It was estimated with and without year dummies. The results confirmed the positive association between other workers of FHS team and ACSH using fixed effects and OLS. A negative association between theses variables was found only in estimations without year dummies.

Column (2) add hospital beds. The coefficient is positive and statistically significant. As expected, it shows that municipalities with more hospital beds is associated with more hospitalization.

The percentage of female illiteracy, column (3), was not statistically significant, even though the coefficient had the expected sign. Additional estimations showed a positive relationship between female illiteracy and ACSH (Table A2). However, it was statistically significant only for specifications without year dummies.

Column (4) adds the GDP per capita. The variable has a negative and statistically significant effect on hospitalization. The column (6) include household facilities. The results show that percentage of households with sewage and trash collection are negatively associated with ACSH among children. This is also the most complete specification and all the coefficients and the p-values remain relatively similar.

Table 6- Estimation results for ACSH among children using System GMM

	(1)	(2)	(3)	(4)	(5)	(6)
$ACSH_{t-1}$	0.887***	0.866***	0.860***	0.857***	0.858***	0.869***
	(0.00801)	(0.0128)	(0.0139)	(0.0146)	(0.0147)	(0.0137)
PC Physician	-4.840***	-4.191**	-4.042**	-4.058**	-4.081**	-4.505***
	(1.664)	(1.698)	(1.692)	(1.693)	(1.700)	(1.696)
Other FHS team	1.901***	1.912***	1.893***	1.887***	1.896***	2.017***
	(0.574)	(0.572)	(0.572)	(0.575)	(0.580)	(0.603)
Hospitalbeds		0.176**	0.222**	0.241**	0.237**	0.168*
		(0.0867)	(0.0955)	(0.101)	(0.103)	(0.0978)
Female illiteracy (%)			0.00922	0.00464	0.000604	-0.126
			(0.152)	(0.154)	(0.155)	(0.161)
Gdppc				-0.00002*	-0.00003*	-0.00003*
				(0.00001)	(0.00001)	(0.00001)
Area density					-0.00003	-0.00005
					(0.00007)	(0.00007)
Sewage (%)						0.0433***
						(0.0126)
Trash collection (%)						-0.0323*
						(0.0186)
Constant	8.396***	2.906	1.621	1.664	1.813	4.628
	(2.425)	(4.236)	(4.448)	(4.461)	(4.571)	(3.883)
Year Dummies	YES	YES	YES	YES	YES	YES
Observations	26,922	26,922	26,922	23,076	23,076	23,076
N of municipalities	3,846	3,846	3,846	3,846	3,846	3,846
Instruments	14	15	16	17	18	20
Hansen/Sargan test	6.25	4.34	3.8	3.84	3.83	0.21
AR1 test	-28***	-26.57***	-26.32***	-26.19***	-26.17***	-26.50***
AR3 test	0.18	0.21	0.21	0.22	0.22	4.74
Wald Chi2	1795.97***	1475.38***	1297.69***	1172.76***	1087.97***	1021.74***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.1 Spatial dynamic panel model

The analyses of hospitalization rate may be affected by neighboring municipalities. The density of hospital beds and the density of PCPs of the neighbourhood are expected to impact the population's health. Thus, it is relevant to perform a diagnostic of spatial dependence of these variables.

Table 7 shows the Moran's I statistic and it confirms the spatial correlation of PCPs and hospital beds. The results indicate that is possible to reject the null hypothesis of spatial randomness at the significance level of 1%. The Moran scatterplots indicate positive spatial correlation. In general, positive spatial correlation denotes that municipalities with high (low) value of the variable tend to be surrounded by high (low) value of this variable in the neighboring municipalities.

The analysis of Moran's I statistic suggest to use the 8-nearest neighbors to define the spatial weight matrix.

Table 7- Moran's I statistics for Primary Care Physician (PCP) and Hospital Bed (HB), 2005-2012

	n=5	**n=8**	**n=12**	**Queen**	**Rook**
PCP05	0.196 (0.001)	0.191 (0.001)	0.184 (0.001)	0.186 (0.001)	0.183 (0.001)
PCP06	0.189 (0.001)	0.180 (0.001)	0.175 (0.001)	0.177 (0.001)	0.175 (0.001)
PCP07	0.204 (0.001)	0.194 (0.001)	0.185 (0.001)	0.192 (0.001)	0.191 (0.001)
PCP08	0.183 (0.001)	0.177 (0.001)	0.169 (0.001)	0.171 (0.001)	0.170 (0.001)
PCP09	0.162 (0.001)	0.157 (0.001)	0.152 (0.001)	0.150 (0.001)	0.148 (0.001)
PCP10	0.165 (0.001)	0.163 (0.001)	0.156 (0.001)	0.156 (0.001)	0.154 (0.001)
PCP11	0.176 (0.001)	0.172 (0.001)	0.163 (0.001)	0.170 (0.001)	0.169 (0.001)
PCP12	0.175 (0.001)	0.167 (0.001)	0.160 (0.001)	0.162 (0.001)	0.162 (0.001)
HB05	0.100 (0.001)	0.100 (0.001)	0.100 (0.001)	0.094 (0.001)	0.094 (0.001)
HB06	0.101 (0.001)	0.102 (0.001)	0.103 (0.001)	0.098 (0.001)	0.098 (0.001)
HB07	0.111 (0.001)	0.109 (0.001)	0.108 (0.001)	0.107 (0.001)	0.107 (0.001)
HB08	0.106 (0.001)	0.105 (0.001)	0.104 (0.001)	0.102 (0.001)	0.103 (0.001)
HB09	0.100 (0.001)	0.101 (0.001)	0.102 (0.001)	0.097 (0.001)	0.098 (0.001)
HB10	0.092 (0.001)	0.098 (0.001)	0.099 (0.001)	0.090 (0.001)	0.090 (0.001)
HB11	0.090 (0.001)	0.096 (0.001)	0.098 (0.001)	0.088 (0.001)	0.088 (0.001)
HB12	0.089 (0.001)	0.096 (0.001)	0.098 (0.001)	0.089 (0.001)	0.089 (0.001)

P-value in parentheses

Table 8 reports the estimate using spatial dynamic panel data, equation (2). The estimate includes two spatial variables, hospital beds and number of PCPs, which allow spatial interactions between neighboring units. Both variables are relevant in explaining ACSH among children. The signs of the coefficients are consistent with the variables considering the effects of the units. They show that number of hospital beds in the neighborhood is positively linked to hospitalization, whereas number of PCPs in the neighborhood is negatively linked to preventable hospitalization.

Table 8- Estimation results for ACSH among children including spatial lags and using System GMM

	(1)
$ACSH_{t-1}$	0.845***
	(0.0207)
PC Physician	-3.711**
	(1.712)
Other FHS team	1.735***
	(0.621)
Hospitalbeds	0.169*
	(0.0881)
Female illiteracy (%)	0.171
	(0.367)
Gdppc	-0.0001**
	(0.00002)
Area density	-0.0001
	(0.00006)
Sewage (%)	0.0775***
	(0.0206)
Trash collection (%)	-0.0941**
	(0.0366)
LagHospitalbeds	0.756**
	(0.325)
LagPCP	-1.741*
	(0.918)
Constant	-8.497***
	(3.141)
Year Dummies	YES
Observations	19,230
N of municipalities	3,846
Instruments	21
Hansen/Sargan test	2.06
AR1 test	-23.77***
AR3 test	1.15
Wald Chi2	724.31***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In addition, we estimated the equation (2) including all Brazilians municipalities (Table 9). The previous results are based on municipalities that have at least one hospital bed. Municipalities without hospital beds were dropped from the estimations since the non-local availability of hospital beds could reduce the number of hospitalization even when it is necessary. Table 8 reports the results for full sample, 5,564 municipalities. Column (1) of the table 9 is the same model presented in the table 8.

Table 9- Estimation results for ACSH among children using System GMM, full sample

	(1)
$ACSH_{t-1}$	0.841***
	(0.0203)
PC Physician	-2.434*
	(1.242)
Other FHS team	1.393***
	(0.460)
Hospitalbeds	0.0916
	(0.0575)
LagHospitalbeds	0.677**
	(0.284)
LagPCP	-0.866
	(0.593)
Gdppc	-0.00008**
	(0.00002)
Female illiteracy (%)	-0.0304
	(0.255)
Area density	-0.00006
	(0.00006)
Sewage (%)	0.0776***
	(0.0171)
Trash collection (%)	-0.0598**
	(0.0260)
Constant	5.149
	(3.284)
Year Dummies	YES
Observations	27,820
N of municipalities	5,564
Instruments	21
Hansen/Sargan test	3.26
AR1 test	-24.65***
AR3 test	0.78
Wald Chi2	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The number of PCPs is negatively associated with the hospitalization for ambulatory care sensitive conditions among children (Table 9). After including all municipalities, the coefficient of hospital beds is no longer statistically significant. However, the number of hospital beds in the neighbourhood is positive and statistically significant. Other control variables, GDP per capita, sewage and trash collection still remain relevant in explaining hospitalization. The lagged dependent variable evidences the high degree of persistence in the preventable hospitalization among children in Brazilian municipalities. The tests show that the instruments are valid and there is no third order serial correlation in the residuals.

4 DISCUSSION

The association between primary care and health outcomes is well described in the literature, including for children (STARFIELD et al., 2005). In this study, the results show the effect of primary care physicians on preventable hospitalization among children under five years old. This relationship remains significant after controlling for various socioeconomic characteristics. Additionally, this study uses a robust methodological approach, spatial dynamic panel data, and a longitudinal database.

Previous studies have showed that infants with at least the recommended number of doctor visits by The American Academy of Pediatrics had a lower adjusted rate of emergency department visits and hospitalization for ambulatory care sensitive conditions (HAKIM; BYE, 2001; PITTARD et al., 2007). Similar result was showed by Ladikta et al. (2005), which increase PCP by one standard deviation reduces the ACSH rate by 0.239 standard deviations. The relationship between primary care and ACSH rates have also been evaluated by conditions. Monahan et al. (2013) found that gastroenteritis hospitalization rates were associated with increasing coverage of primary care in Bahia, Northeast Brazil. Pamponet (2014) showed the negative effect of primary care on hospitalization rate for pneumonia in Brazilian municipalities. Both studies, Monahan et al. (2013) and Pamponet (2014) are longitudinal analyses and use fixed effects. These conditions, gastroenteritis and pneumonia, are among the most common hospital admissions of children. Our results provides additional evidence of a negative association between the number of primary care physicians and children health. The results indicated that the increase of PCPs lead to lower rates of hospitalization for ambulatory care sensitive conditions among children.

Hospital beds indicated a positive and significant effect on ACSH. This results was expect since municipalities with more hospital beds may record a higher number of admissions (DELAMATER et al., 2013). The association between the number of hospital beds and higher hospitalization is well-know, as showed by Lugo-Palacios and Cairns (2015), Carvalho et al. (2015), Macinko et al. (2011). Table 9 shows that after considering all municipalities, with and without hospital beds, the municipal number of hospital beds is no longer significant to explain hospitalization. These results confirm that geographical accessibility is a relevant component of access to hospital. Individuals are more discouraged by long travel times for health service and tend to seek for other nearest provides (LUO; WANG, 2003).

In terms of spatial effects, the results indicate that the numbers of hospital beds and PCPs in the neighborhood are associated with ACSH. The number of hospital beds of the surrounding areas is positively associated with the total number of hospitalization. It indicates that even that the individuals tend to settle for health services in nearby locations, the availability of this services in the neighborhood is relevant. Similar result is found for PCP, the coefficient is negatively related to ACSH. These finds suggest that the population mobility to nearby areas is a relevant factor to health care access.

Hospitalizations for ambulatory care sensitive conditions are found related to GDP per capita in both developed and developing countries (MAFRA, 2010; ROSANO et al., 2013). Even though income level and income inequalities are important variables to explain preventable hospitalization rate (AGABITI et al., 2009), Preston (1975) argues that national income is possibly the best indicator of living standards in a country. Once national income includes all final products, which may influence health’s variables, this indicator is more appropriate than on another socioeconomic variable.

The estimations include two variables related to household facilities, sewage and trash collection. They are widely associated by the literature with some preventable diseases. Diarrhea, gastroenteritis, leptospirosis, poliomyelitis and salmonellosis are examples of diseases caused by untreated sewage or sewage contaminated water (ASHBOLT, 2004; PAYMENT et al., 1991). On the other hand, garbage burning is one important source of pollution. The environmental pollution of waste dumping can have health effects of short and long-term, including congenital anomalies, asthma, respiratory infection, headache, and respiratory and cardiovascular diseases (MATTIELLO et al., 2013; TRIASSI et al., 2015). Our results show that only trash collection had the expected sign. This may occur due to dependent variable, hospitalization, include all preventable disease, and not only diseases identified as being associated with household facilities.

It is noteworthy that two variable did not show the expected result. First, we expected that the number of other workers of FHS team was negatively associated with ACSH. The results show a positive relationship between them. Previous literature has indicated the inverse association between hospitalization and FHS in Brazil (CECCON et al., 2014; MACINKO et al., 2011). Additional results showed a negative association between these variables only in estimations without year dummies. Even estimates including FHS coverage (instead of other FHS team) showed positive sign after including year dummies. All cited studies for ACSH in Brazil don't include year dummies. Second, female illiteracy also was expected to be found with positive sign and significant. Although the sign is consistent with expected, it is not statistically significant. Additional estimations indicated a positive and statically significant relationship between illiteracy and ACSH only for specifications without year dummies. These three results, other FHS team, FHS coverage and female illiteracy, reveal that after control for year effects they didn't show the expected sign. All year dummies in all models were statically significant at the 1% level, which indicate the relevance of capturing aggregate trends.

5 CONCLUSIONS

The Brazilian policy regarding public health system has given substantial importance to primary care in recent decades, potentially providing lessons for other developing countries. The objective of this study has been to investigate the relationship between number of primary care physicians in local areas and hospitalization for ambulatory care sensitive conditions among children under five years old. The results suggest that primary care physicians play an important role in accounting for the reduction of hospitalization for ambulatory care sensitive condition among children. In addition, spatially lagged variables indicate that there is a spatial spillover related to hospital beds and number of PCPs.

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APPENDIX

Table A1 – Brazilian list of ambulatory care sensitive hospitalization by diagnostic groups (ICD-10)

ICD-10 diagnosis	Code used
Diseases preventable by immunization and sensitive conditions	A15.0 to A15.9; A16.0 to A16.9; A17.0 to A17.9; A18; A19; A33 to A37; A51 to A53; A95; B05; B06; B16; B26; B50 to B54; B77; G00.0; I00 to I02
Infectious gastroenteritis and complications	A00 to A09; E86
Anemia	D50
Nutritional deficiencies	E40 to E46; E50 to E64
Ear, nose and throat infections	H66; J00 to J03; J06; J31
Bacterial pneumonia	J13; J14; J15.3; J15.4; J15.8; J15.9; J18.1
Asthma	J45; J46
Lung diseases	J20; J21; J40 to J44; J47
Hypertension	I10; I11
Angina	I20
Heart failure	I50; J81
Cerebrovascular diseases	G45; G46; I63 to I67; I69
Diabetes Militus	E10.0 to E10.9; E11.0 to E11.9; E.12.0 to E12.9; E13.0 to E13.9; E14.0 to E14.9
Epilepsies	G40; G41
Kidney and urinary tract infections	N10 to N12; N30; N34; N39.0
Infections of the skin and subcuraneous tissues	A46; L01 to L04; L08
Inflammatory diseases of female pelvic organs	N70 to N73; N75; N76
Gastrointestinal ucler	K25 to K28; K92.0 to K92.2
Prenatal and childbirth-related diseases	A50; 023; P35.0

Source: Ministry of Health, 2008.

Table A1 – Estimation results for ACSH and “other FHS team” among children using different estimation techniques

	OLS	OLS	Fixed Effects	Fixed Effects
Other FHS team	-0.157**	0.123*	-0.771***	0.271***
	(0.0700)	(0.0726)	(0.0724)	(0.0842)
Additional controls	NO	NO	NO	NO
Year Dummies	NO	YES	NO	YES
Observations	30768	30768	30768	30768
N of municipalities			3846	3846
F- test	5.05	54.65	113.39	188.8

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A2 – Estimation results for ACSH and female illiteracy among children using different estimation techniques

	OLS	OLS	Fixed Effects	Fixed Effects
Female illiteracy (%)	0.414***	0.0877	0.872***	0.0408
	(0.152)	(0.152)	(0.133)	(0.132)
Additional controls	NO	NO	NO	NO
Year Dummies	NO	YES	NO	YES
Observations	30768	30768	30768	30768
N of municipalities			3846	3846
F- test	7.45	54.33	43.17	187.45

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1