Web Appendix

A. Brazilian list of ambulatory care-sensitive conditions

The official list of ACSC-related diseases adopted by the Brazilian Ministry of Health comprises 19 diseases or health conditions.[1] It was based on the conceptual framework proposed by Caminal et al.,[2] which takes into account only hospitalizations that have a strong association with primary healthcare resolution (immunization, early diagnosis, control and monitoring of chronic diseases, and health promotion).

Various criteria were used to guide the inclusion or exclusion of the diagnosis in the Brazilian list of ASCSs. First, the availability of scientific evidence indicating the cause of hospitalization is sensitive to primary health care. Second, the condition must be easily diagnosed. Third, the condition should be considered a major health problem, excluding rare events. Fourth, primary health care would be able to solve the problem or prevent complications that lead to hospitalisation. Fifth, the diagnosis must not be driven by financial incentives.

The most recent version of the Brazilian list of ASCSs was published through Regulation SAS/MS No. 221 on 17th April 2008.[3] It is shown in Table A1. The 19 health conditions contained within this list were the basis for the analysis of avoidable hospitalisations by condition, the results of which are presented in Figure 3 of the main paper.

B. Definition of variables

For each variable used in the analysis, Table A2 describes its definition, year for which data were available and the source of data. This information is given for the study outcomes, the exposure variable and the municipality characteristics.

C. Empirical strategy

Our general empirical approach was to exploit expansion of the FHS to compare changes in avoidable hospitalisation in municipalities where the programme was implemented relative to municipalities in the same state and year where there was no expansion of the programme. Let m index municipalities (m = 1, …, 5,506), t index years (t = 2000, …, 2014), and s index state (s = 1, …, 26). We modelled an outcome of interest y_{mt}, which could be one of several measures of avoidable hospitalisations or primary care consultations. Our exposure variable, FHS_{mt}, was the coverage of the FHS in municipality m at time t. The underlying model we are interested in the relationship between FHS coverage and avoidable hospitalisations. We assumed that

$$y_{mt} = \beta FHS_{mt} + \alpha_m + \gamma_{st} + x_{mt}\delta + \varepsilon_{mt} \tag{1}$$

where α_m was a municipality effect, γ_{st} was state-year effect, x_{mt} was a set of municipality characteristics, and ε_{mt} was a municipality-year shock. The parameter β was the effect of the FHS on the study outcome.

We estimated the model in first differences. The first-difference operator was represented by Δ, which subtracts the previous value for each observation; for example, $\Delta y_{mt} = y_{mt} - y_{m(t-1)}$. We estimated the model in first differences, rather than with municipality fixed effects, because the data showed highly persistent shocks as demonstrated by the fact that the standard test for serial correlation rejected the null hypothesis of no serial correlation.[4] Our estimating equation was

$$\Delta y_{mt} = \beta \Delta FHS_{mt} + \Delta\gamma_{st} + \Delta x_{mt}\delta + \Delta\varepsilon_{mt} \tag{2}$$

The municipality fixed effects dropped out due to the differencing and γ_{st} entered the regression as a state-year fixed-effect. Our set of controls x_{mt} included controls for the human development index, Gini coefficient, monthly income per capita, percentage of population below the poverty line, percentage of the population aged 15 years or above who cannot read or write, the number of public and private hospital beds per 1000 population and the share of the population by age group (0 to 4 years, 5 to 19 years, 20 to 59 years, 60 to 69 years, 70 to 79 years, and over 80 years).

We presented both unadjusted estimates (with no municipality controls – model 1) and adjusted estimates (with municipality controls – model 2). Each regression was weighted by the municipality population to reveal the effect of the FHS on the average person rather than the average municipality. This also addresses the fact that hospitalisation rates in municipalities with smaller populations will be more imprecise so deals with heteroskedasticity associated with the variation in precision. We clustered standard errors at the municipality level.[5]

We conducted several additional analyses. First, we examined the effect of the FHS on hospital admissions for each of the 19 ACSCs separately and plotted the estimates with 95% confidence intervals. The specification was analogous to equation (2) except that the outcome was specific to the condition under investigation. Second, we explored the extent to which avoidable hospital admissions in municipality i may have been influenced by expansion of the FHS in *other* municipalities. We anticipated that such “spillovers” could arise if people travel across municipality borders to seek hospital care. We used ArcGIS (version 10·3) to identify each municipality’s nearest neighbour j based on the distance between centroids. We extended our estimating equation

$$\Delta y_{imt} = \beta_1 \Delta FHS_{imt} + \beta_2 \Delta FHS_{jmt} + \Delta\gamma_{st} + \Delta x_{imt}\delta_1 + \Delta x_{jmt}\delta_2 + \Delta\varepsilon_{imt} \qquad (3)$$

The spillover effect – from expansion of the FHS in the nearest municipality – is captured by β_2.

D. Robustness

We examined the sensitivity of the main findings to a wide range of robustness checks. The first set of robustness checks used pre-trends as a standard diagnostic tool for bias in panel data models. As stated in Gentzkow et al.,[6] if the relationship between ΔFHS_{mt} and Δy_{mt} is causal then ΔFHS_{mt} cannot be correlated with past values of Δy_{mt}. Evidence of diverging pre-trends would suggest that the observed relationship is driven by omitted variables. We implemented this robustness check by including leads and lags of the change in FHS coverage and plotting the coefficients α^k in the following estimating model:

$$\Delta y_{mt} = \sum_{k=-7}^{7} \alpha^k \Delta FHS_{m(t-k)} + \Delta\gamma_{st} + \Delta x_{mt}\delta + \Delta\varepsilon_{mt} \qquad (4)$$

Coefficients α^k for $k < 0$ were plotted on the left-hand side of the figure to show the relationship between current changes in FHS coverage and past changes in avoidable hospitalisations, while coefficients α^k for $k > 0$ were plotted on the right-hand side of the figure to show the relationship between current changes in FHS coverage and future changes in avoidable hospitalisations. We conducted this analysis for both avoidable hospitalisations and primary care consultations.

The results of the pre-trends robustness check are shown in Figure A1. Panel A shows little evidence of large diverging pre-trends for avoidable hospitalisations, suggesting that our results are unlikely to be strongly biased. There is a small positive on-impact effect on avoidable hospitalisations as well as persistence of a positive effect the following year. Panel B reports the coefficients α^k for primary care consultations, showing that there was a large positive on-impact effect and no obvious pre-trends.

We examined the sensitivity of our main findings to a battery of further robustness checks. First, we ran the first difference model without population weights. Second, we included a set of political dummies indicating the party of the mayor in each municipality, since left wing parties were more likely to adopt the program in any given year.[7] Third, instead of running the model in first differences, we used long differences by considering two- and three-year differences. Fourth, instead of first-differencing, we estimated a model with municipality fixed effects. Fifth, we used a random effects model. The key distinction between fixed and random effects is that the former permits correlations between the unobserved time-invariant intercept (individual effects) and the covariates, while the latter does not.[8] Sixth, we ran regression models with an autoregressive error structure – specifically an AR(1) and AR(2) error structure.

Table A3 shows the results from these robustness checks for avoidable hospitalisations and primary care consultations. The effect of the FHS on avoidable hospitalisations remained positive in all cases and mostly statistically significant. When no population weights were used, the effect was positive but statistically indistinguishable from zero at conventional levels of significance. The effect of the FHS on primary care consultations remained positive and statistically significant in all cases.

References

1. Alfradique ME, Bonolo PF, Dourado I, et al. Internações por condições sensíveis à atenção primária: a construção da lista brasileira como ferramenta para medir o desempenho do sistema de saúde (Projeto ICSAP – Brasil). *Cad Saude Publica*, 2009; **25** (6): 1337-49.
2. Caminal-Homar J, Casanova-Matutano C. La evaluación de la atención primaria y las hospitalizaciones por ambulatory care sensitive conditions. Marco conceptual. *Aten Primaria*, 2003; **31**: 61-5.
3. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. PORTARIA Nº 221, DE 17 DE ABRIL DE 2008. http://bvsms.saude.gov.br/bvs/saudelegis/sas/2008/prt0221_17_04_2008.html (Accessed July 12, 2016)
4. Wooldridge J. Econometric Analysis of Cross Section and Panel Data. 2nd Edition. The MIT Press, Cambridge, 2010.
5. Bertrand M, Duflo E, Mullainathan S. How Much Should We Trust Differences-in-Differences Estimates? *Quarterly Journal of Economics*, 2004, **119** (1): 249–75.
6. Gentzkow M, Shapiro JM, Sinkinson M. The Effect of Newspaper Entry and Exit on Electoral Politics. *American Economic Review*. Dec 2011, Vol. **101**, No. 7: 2980-3018
7. Rocha R, Soares RR. Evaluating the impact of community-based health interventions: evidence from Brazil's Family Health Program. *Health Econ.*, 2010 **19**: 126–158.
8. Gunasekara FI, Richardson K, Carter K, Blakely T. Fixed effects analysis of repeated measures data. *Int. J. of Epidemiol* 2014 Feb; **43** (1): 264-9.

Tables

Table A1. The Brazilian list of ambulatory care sensitive conditions by groups of diagnosis according to the International Classification of Diseases (ICD-10)

Group of diagnosis	ICD-10
Preventable diseases by immunization and avoidable conditions	A15.0-A15.3, A15.4-A15.9, A16.0-A16.2, A16.3-A16.9, A17.0, A17.1-A17.9, A18, A19, A33-A35, A36, A37, A51-A53, A95, B05, B06, B16, B26, B50-B54, B77, G00.0, I00-I02
Infectious gastroenteritis and complications	A00-A09, E86
Iron deficiency anaemia	D50
Nutritional deficiency	E40-E46, E50-E64
Ear, nose and throat infections	H66, J00, J01, J02, 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, J41, J42, J43, J44, J47
Hypertension	I10, I11
Angina pectoris	I20
Heart failure	I50, J81
Cerebrovascular diseases	I63-I67, I69, G45-G46
Diabetes mellitus	E10.0, E10.1, E11.0, E11.1, E12.0, E12.1, E13.0, E13.1, E14.0, E14.1, E10.9, E11.9, E12.9, E13.9 E14.9, E10.2-E10.8, E11.2-E11.8, E12.2-E12.8, E13.2-E13.8, E14.2-E14.8
Epilepsy	G40, G41
Kidney and urinary tract infection	N10, N11, N12, N30, N34, N39.0
Infections of the skin and subcutaneous tissue	A46, L01, L02, L03, L04, L08
Inflammatory diseases of female pelvic organs	N70, N71, N72, N73, N75, N76
Gastric ulcer	K25-K28, K92.0, K92.1, K92.2
Prenatal and childbirth-related diseases	O23, A50, P35.0

Source: Ministry of Health’s Order n. 221, 17th April 2008 (Portaria SAS/MS n. 21, de 17 de abril de 2008).

Table A2. Description of variables used in the analysis

Variable	Definition	Year available	Source
Exposure variable			
FHS coverage	Total number of the FHS teams in each municipality / population in each municipality x 3,450 population	Data available annually, from 2000 to 2014	Department of Primary Care from the MoH (DAB/SAS/MS)
Study outcomes			
Hospitalisations for ACSC (per 1,000 pop)	Number of ACSC hospitalisations of under 80s in each municipality / population under 80 in each municipality x 1,000 inhabitants	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Primary care consultations (per 1,000 pop)	Total number of medical consultations at FHS level in each municipality/ population under 80 in each municipality x 1,000 inhabitants	Data available annually, from 2000 to 2014	Primary Care Information System from DATASUS (SIAB/SUS)
Hospital days for ACSC (per 1,000 pop)	Total number of inpatient days for ASCS hospitalisations of under 80s in each municipality/ population under 80 in each municipality x 1,000 population	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Hospital expenditure on ACSC (R$ per capita)	Total reimbursement made by the MoH for ACSC hospitalization in under 80s in each municipality/ total population under 80 x 1,000 population	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Municipality characteristics (covariates)			
Gini coefficient	Gini coefficient of income inequality based on national demographic census carried out in 2000 and 2010 by the Brazilian Institute of Geography and Statistics (IBGE). It ranges from zero (equality) to one (inequality).	Data available in 2000 and 2010. We estimated the annual values from 2001-2009 by linear interpolation and 2011-2013 by linear extrapolation	Atlas for human development in Brazil from the United Nations Development Programme
Human development index	HDI is a composite statistic of life expectancy, education, and income per capita indicators based on national demographic census carried out in 2000 and 2010 by the Brazilian Institute of Geography and Statistics (IBGE). It ranges from zero (worst) to one (best).	Data available in 2000 and 2010. We estimated the annual values from 2001-2009 by linear interpolation and 2011-2013 by linear extrapolation	Atlas for human development in Brazil from the United Nations Development Programme
Monthly income per capita (R$)	Average income in Brazilian currency based on 2000 and 2010 censuses carried out by IBGE. We did not adjust for inflation	Data available in 2000 and 2010. We estimated the annual values from 2001-2009 by linear interpolation and 2011-2013 by linear extrapolation	Atlas for human development in Brazil from the United Nations Development Programme
Below the poverty line	Percentage of population in each municipality living below the national poverty line (R$ 140.00 per capita)	Data available in 2000 and 2010. We estimated the annual values from 2001-2009 by linear interpolation and 2011-2013 by linear extrapolation	Atlas for human development in Brazil from the United Nations Development Programme
Illiteracy	Percentage of the population aged 15 years or above who cannot read or write	Data available in 2000 and 2010. We estimated the annual values from 2001-2009 by linear interpolation and 2011-2013 by linear extrapolation	Atlas for human development in Brazil from the United Nations Development Programme
Share of population aged 0-4 years	Proportion of under 5s in each municipality/ total population in each municipality under 80	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Share of population aged 5-19 years	Proportion of people aged between 5 and 19 years in each municipality/ total population in each municipality under 80	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)

Share of population aged 20-59 years	Proportion of people aged between 20 and 59 years in each municipality/ total population in each municipality under 80	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Share of population aged 60-69 years	Proportion of people aged between 60 and 69 years in each municipality/ total population in each municipality under 80	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Share of population aged 70-79 years	Proportion of people aged between 70 and 79 years in each municipality/ total population in each municipality under 80	Data available annually, from 2000 to 2014	Hospital Information System from DATASUS (SIH/SUS)
Hospital beds per 1000 population	Total number of available hospital beds (public and private) in each municipality / population in each municipality x 1000 inhabitants.	Data available annually, from 2000 to 2014	National Register of Health Establishments from DATASUS (CNES/SUS)

Table A3. Effect of FHS on additional outcomes

Outcome	Average length of stay for ACSC (days per admission)		Hospital expenditure on ACSC (R$ per admission)	
	Model 1 (95% CI)	**Model 2 (95% CI)**	**Model 1 (95% CI)**	**Model 2 (95% CI)**
FHS coverage	-0.02(-0.1 to 0.05)	-0.02(-0.09 to 0.05)	-7.0 (-19.0 to 5.1)	-0.5 (-12.3 to 11.3)
Observations	77,084	77,056	77,084	77,056
Municipalities	5,506	5,504	5,506	5,504
Mean (2014)	6.2	6.2	1,045	1,045

Notes: *p<0.1; ** p<0.05; *** p<0.01. Period is 2000-2014. Confidence intervals are shown in parentheses, based on standard errors that are clustered by municipality. Data are weighted by the municipality population. Models are estimated in first differences and include state-year fixed effects. Model 1 presents unadjusted estimates (no covariates). Model 2 present adjusted estimates (covariates included).

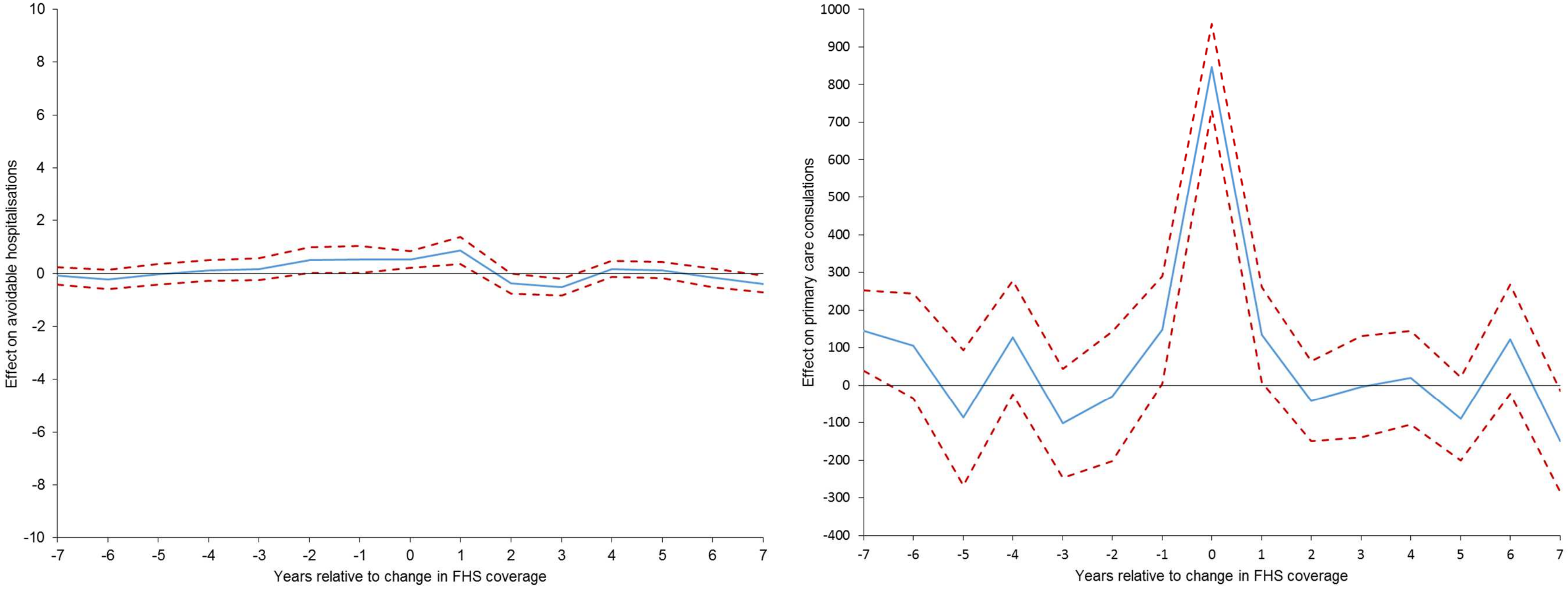
Table A4. Sensitivity of results to alternative specifications

Variable	Hospitalisations for ACSC (per 1,000 population)	Primary care consultations (per 1,000 population)
1. Baseline	0.6 *** (0.3 to 0.9)	866 *** (762 to 970)
2. No population weights	0.2 (-0.2 to 0.6)	764 *** (432 to 1,097)
3. Mayoral political party controls	0.6 *** (0.3 to 0.9)	867 *** (763 to 970)
4. Three-year long differences	0.8 *** (0.2 to 1.3)	1,184 *** (911 to 1,458)
5. Two-year long differences	0.9 *** (0.4 to 1.4)	1,017 *** (894 to 1,140)
6. Fixed effects	0.7 *** (0.2 to 1.3)	1,021 *** (954 to 1,089)
7. Random effects	0.5 *** (0.3 to 0.7)	871 *** (754 to 988)
8. AR(1) error structure	0.6 *** (0.2 to 0.9)	967 *** (886 to 1,049)
9. AR(2) error structure	0.5 *** (0.2 to 0.9)	1,016 *** (928 to 1,103)

Notes: *p<0.1; ** p<0.05; *** p<0.01. Each cell reports results from a regression model. The coefficient estimate on FHS coverage is reported, along with the 95% CI in parentheses and the p value in squared brackets. The baseline model refers to Model 2 in Table 2 of the main paper.

Figures

Figure A1. Effect on avoidable hospitalisations (Panel A) and primary care consultations (Panel B) in years relative to the change in FHS coverage



Notes: Figure plots coefficients from a regression of change in avoidable hospitalisation (Panel A) and primary care consultations (Panel B) on a set of leads and lags of the change in FHS coverage. Each Figure is scaled according to the 2014 mean of the outcome. Period is 2000-2014. 95% confidence intervals are shown by the dotted lines and are based on standard errors that are clustered by municipality. Data are weighted by the municipality population. All models are estimated in first differences and include state-year fixed effects and controls for municipality characteristics.