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Pay for performance in primary care: the contribution of the Programme for Improving Access and Quality of Primary Care (PMAQ) on avoidable hospitalisations in Brazil, 2009–2018

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ABSTRACT

Background Evidence on the effect of pay-for-performance (P4P) schemes on provider performance is mixed in low-income and middle-income countries. Brazil introduced its first national-level P4P scheme in 2011 (PMAQ-Brazilian National Programme for Improving Primary Care Access and Quality). PMAQ is likely one of the largest P4P schemes in the world. We estimate the association between PMAQ and hospitalisations for ambulatory care sensitive conditions (ACSCs) based on a panel of 5564 municipalities.

Methods We conducted a fixed effect panel data analysis over the period of 2009–2018, controlling for coverage of primary healthcare, hospital beds per 10 000 population, education, real gross domestic product per capita and population density. The outcome is the hospitalisation rate for ACSCs among people aged 64 years and under per 10 000 population. Our exposure variable is defined as the percentage of family health teams participating in PMAQ, which captures the roll-out of PMAQ over time. We also provided several sensitivity analyses, by using alternative measures of the exposure and outcome variables, and a placebo test using transport accident hospitalisations instead of ACSCs.

Results The results show a negative and statistically significant association between the rollout of PMAQ and ACSC rates for all age groups. An increase in PMAQ participating of one percentage point decreased the hospitalisation rate for ACSC by 0.0356 (SE 0.0123, p=0.004) per 10 000 population (aged 0–64 years). This corresponds to a reduction of approximately 60 829 hospitalisations in 2018. The impact is stronger for children under 5 years (−0.0940, SE 0.0375, p=0.012), representing a reduction of around 11 936 hospitalisations. Our placebo test shows that the association of PMAQ on the hospitalisation rate for transport accidents is not statistically significant, as expected.

Conclusion We find that PMAQ was associated with a modest reduction in hospitalisation for ACSCs.

Key questions

What is already known?

- ► Despite the rapid expansion over the last decade, it is unclear the contribution of pay-for-performance (P4P) schemes in low-income and middle-income countries, particularly when related to health outcomes.
- ► Brazilian National Programme for Improving Primary Care Access and Quality (PMAQ) is likely one of the largest P4P schemes in the world, reaching around 39 000 Family Health Teams.

What are the new findings?

- ► We show that expansion of the PMAQ was associated with a modest reduction in avoidable hospitalisations for all age groups, with stronger impact for children under 5 years.
- ► When stratifying by age group and diseases that accounted for a high proportion of ambulatory care sensitive conditions, we found that PMAQ expansion was associated with a reduction in hospitalisations for gastroenteritis for 0–4 years, asthma for 5–19 years and renal disease for 20–64 years.

What do the new findings imply?

- ► The findings provide evidence that P4P can contribute to improve quality of care at primary healthcare setting, particularly by reducing avoidable hospitalisations.

INTRODUCTION

Recent reviews have challenged low-income and middle-income countries (LMICs) that have adopted pay-for-performance (P4P) schemes in primary healthcare (PHC), by showing very low-certainty and evidence about the effect of P4P on provider performance, utilisation of services, patient outcomes and resource use.[1–3] Moreover, evidence from LMICs is skewed towards donor-oriented approaches, since most P4P schemes have been driven and funded by international organisations,[4] often implemented disassociated from existing health system institutions.[5 6] Additionally, the effects of P4P schemes have typically been assessed at only one point in time.[4]

After nearly two decades of continuing reforms and strengthening of PHC,[7] Brazil introduced its first national-level P4P scheme, called the Brazilian National Programme for Improving Primary Care Access and Quality (PMAQ, acronym in Portuguese) in 2011. PMAQ was rolled out over three rounds of implementation: round 1 (November 2011–Mar 2013), round 2 (April 2013–September 2015) and round 3 (October 2015–December 2019). During three rounds, the Brazilian Ministry of Health provided financial incentives for a wide variety of structure, process and outcome indicators,[8] aiming to improve access and quality of PHC. To achieve these goals, some challenges should be overcome, such as poor health facility infrastructure, inadequate working conditions, high turnover of health professionals, low integration of PHC facilities with healthcare networks (secondary and tertiary levels), rare evaluative culture at facility level, and underinvestment in information technologies to support decision-making process.[9]

Participation in PMAQ has increased rapidly over the three rounds of implementation, reaching 38 864 family health teams (FHTs) in the third round, representing 89.5% of the total number of teams across the country in 2018. PMAQ has received RS 13.5 billion (US$ 2.7 billion) from 2011 to 2019. Despite 9 years of implementation, PMAQ is still underevaluated in terms of its effects on endpoint outcomes. Studies relied mainly on descriptive analyses,[10] based on a subset of data on structure, access, service organisation and management indicators, generally for a specific health condition such as diabetes,[11] antenatal care,[12] cervical cancer screening,[13] user's satisfaction[14] and work processes.[15]

Hospitalisation rate for ambulatory care sensitive conditions (ACSCs) have been used as an indirect indicator of the effectiveness and quality of PHC.[16] ACSCs are a set of diseases and health problems for which timely and high-quality PHC reduces the risk of inpatient admission. Previous studies have investigated the relationship between P4P scheme and ACSCs showing mixed results. The Portuguese experience showed no significant impact of the P4P scheme on the hospitalisation rate for ACSCs[17]; while the English experience found a reduction on the ACSCs incentivised by the Quality Outcome Framework (QOF).[18 19] In the USA, two out of three states that implemented P4P schemes presented reduction in ACSC hospitalisations.[20] In Brazil, we identified a study that found a decline in hospitalisation for ACSCs due to PMAQ in the first 4 years of PMAQ implementation.[21] However, the latter study covered the first two rounds of PMAQ (2010–2014) and used a dichotomous measure of exposure (=1 if municipality participated in PMAQ), which may not reflect the implementation intensity of PMAQ over time.

By improving access and quality of primary care, it is expected that PMAQ would deliver more prevention and better treatment at PHC level, which would result in fewer hospitalisations for ACSCs. Based on that, the objective of our study is to estimate the association of PMAQ on hospitalisations for ACSCs, using a fixed effect (FE) panel data approach of 5564 municipalities from 2009 to 2018, controlling for observed demographic, socioeconomic and health supply-side covariates.

METHODS

Study setting

Brazil created the Unified Health System (Sistema Único de Saúde - SUS, in Portuguese) in 1990, financed by general taxation and since then it has made consistent progress towards achieving universal health coverage by providing formally under the law, universal, equitable and comprehensive healthcare free of charge at the point of service.[22] Around 75% of the Brazilian population receives healthcare only through the SUS, while 25% have private insurance coverage.[23] PHC was nationally implemented in 1994, focusing on families and communities and integrating medical care with health promotion and public health actions, including epidemiological surveillance.[24] PHC is provided mainly through three channels: (1) the FHT, composed of at least one physician, a nurse, a nurse assistant and a community health agent; (2) the oral health team (OHT), composed of at least one dentist and a dentist assistant and (3) the Family Health Support Unit (NASF), composed of mental health, rehabilitation, nutrition, maternal and childcare staff, pharmacy and social assistance workers.

PMAQ was one of the strategies aimed at improving PHC that occurred simultaneously and as part of a broader set of changes introduced at the federal level. In 2011, when PMAQ was implemented, the National Primary Healthcare Policy was revised,[25] resulting in[26–30]: (1) increasing of financial transfers from the Ministry of Health to PHC and adoption of equity criteria in health resource allocation; (2) expansion of the Family Health Strategy (FHS) modalities that could receive federal funding, including fluvial health facilities that delivery care to populations living in deprived riverside communities; (3) implementation of Requalifica UBS, a programme that provided financial resources to improve the structure of PHC facilities, such as construction and refurbishments; (4) investments in information systems, aiming at implementing a new PHC information system (e-SUS) and telehealth (Telessaúde Brasil Rede); (5) expansion of NASF, including other healthcare workers; (6) expansion of the programmes for health promotion and prevention in schools (Programa Saúde na Escola) and homecare delivery (Programa Melhor em Casa); (7) implementation of the Programme to Value Primary

Healthcare Professionals (PROVAB), which offered training and scholarships for doctors who work in highly vulnerable and deprived areas; and (8) implementation of More Doctor Programme (Programa Mais Médicos) in 2013, involving an emergency expansion of PHC doctors (allowing the hiring of foreign doctors), an increasing number of PHC residency positions, and increasing investments in the infrastructure of PHC facilities.

The PMAQ scheme

The PMAQ scheme was intended to strengthen primary care by increasing resources allocated from the Ministry of Health to municipalities, with the level of resources determined by the performance of primary care teams within the municipality. Municipalities decide whether to disburse financial incentives directly to healthcare providers or teams or to use the financial resources for other purposes related to PHC.[8] Participation in PMAQ is voluntary, and municipalities have autonomy to indicate which of their teams would be engaged in the programme. Only the FHT and the OHT were eligible to participate in the first round of the PMAQ (November 2011–March 2013). NASF was included in the second (April 2013–September 2015) and third rounds (October 2015–December 2019). Only 50% of FHTs within a municipality could participate in the first round of PMAQ. In the following rounds, this restriction did not apply.

Teams are evaluated through self-assessment, routine monitoring and external evaluation, resulting in hundreds of structure, process and outcome indicators in each round (598 in round 1; 914 in round 2; and 660 in round 3).[31] Structural indicators include availability of drugs and equipment, patient's privacy during consultations and procedures, and users' accessibility. Process indicators include content of antenatal care, treatment completion rates, consultation for routine monitoring (ie, diabetes, hypertension, asthma), number of consultations for selected diseases, and proportion of appointments that are scheduled. Outcome indicators include patients' satisfaction, birth weight of children and prevalence of chronic disease.

Study design

We conducted a FE panel data analysis to measure the association of PMAQ on the hospitalisation rate for ACSCs over the period 2009–2018. FE models provide a method for assessing exposure/outcome associations (PMAQ/hospitalisation for ACSCs, in our study) adjusting for time-invariant confounders (municipal characteristics) and measuring time-varying confounders (socioeconomic, demographic, and supply-side variables).[32] The unit of analysis is the municipality because the final decision about the PMAQ engagement is taken at this administrative level. We introduced novel aspect to the model by considering a measure of PMAQ implementation intensity. Instead of having a dichotomous measure of exposure (yes/no), we used the percentage of PMAQ participating teams related to the total number of FHTs for each municipality, which may better reflect the expansion of PMAQ over time (three rounds of PMAQ).

Variables and sources

The primary outcome is the age-adjusted hospitalisation rate for ACSCs, defined as the number of hospitalisations for ACSCs among people under 64 years of age per 10 000 population. Hospital admissions were available at municipal level. We excluded patients aged over 65 years because such individuals are likely to have a high prevalence of other diseases than those related to ACSCs, which may not be affected by timely and high-quality PHC. We used the Brazilian list for ACSCs, which was developed by the Ministry of Health based on the International Classification of Diseases (ICD-10).[33] A complete description of the diseases and health conditions included in the Brazilian list of ACSCs can be found in online supplemental table S1. The list included 19 diseases or health conditions and all of them were incentivised by PMAQ. Additionally, we also included alternative outcomes, such as hospitalisation rate for ACSCs stratified by age group (0–4 years, 5–19 years and 20–64 years) and the most frequent causes of ACSCs (causes that account for more than 10% of hospitalisations for ACSCs). We used age-adjusted hospitalisation rates for adults (aged 20–64 years) and the overall population (aged 0–64 years). Age-adjusted rates were calculated using the direct method of standardisation.[34] Data were extracted from the Hospital Information System (SIH/DATASUS).[35]

Our exposure variable is defined as the percentage of the PMAQ teams in terms of total number of FHT. FHTs include teams of the FHS and primary health teams. The PMAQ participating teams that were assigned as 'unsatisfactory' or 'declassified' by the Ministry of Health were excluded from the database, since these teams have not been exposed to PMAQ scheme during the whole round. This assumption was relaxed in the sensitivity analysis. 'Unsatisfactory' means that teams have not complied with the rules of PMAQ and 'declassified' encompasses three situations: (1) teams have asked to be formally removed from the PMAQ; or (2) teams have refused to be evaluated by the external evaluation; or (3) teams did not have a dental chair. Data were obtained from the Primary Healthcare System (SAPS/Ministry of Health).[36] Although PMAQ started in November 2011, municipalities and FHT had been aware of its existence since very early 2011. On this basis, we considered 2011 as initial year of PMAQ programme.

We included a set of covariates usually associated with hospitalisation rate for ACSCs that could be regarded as confounding variables such as: coverage of PHC, hospital beds per 10 000 population, education index, gross domestic product (GDP) per capita (adjusted by General Price Index) and population density. For education index, we used the FIRJAN Index of Municipal Development for education (IFDM), which includes six indicators: (1) enrolment in early childhood education, primary school leaver, age-grade distortion in primary school, percentage of teachers with a degree qualification in primary school, average daily lesson hours in primary school and Basic Education Development Index result in primary school.[37] The education index ranges from 0 to 1, where higher values indicate greater development of the municipal units. For the education index and GDP per capita, data were not available for 2018 and 2017–2018, respectively, in which case we estimated annual values by linear extrapolation. PHC coverage was obtained from the Primary Healthcare System (SAPS/Ministry of Health),[36] hospital beds from the National Registry of Health Facilities (CNES/DATASUS),[38] education index from the Federation of Industries of the State of Rio de Janeiro (FIRJAN),[37] and GDP per capita and population were from the Brazilian Institute of Geography and Statistics (IBGE).[39] All covariates were available at municipal level.

Statistical analyses

Descriptive analyses were undertaken, including national trends of overall and most frequent ACSC hospitalisation rates stratified by age group. FE panel data regressions were used to assess the association between municipal-level hospitalisation rates for ACSCs and the percentage of FTHs that participated in PMAQ.

The equation for the FE model can be written as:

$$ACSC_{it} = \alpha + \gamma PMAQ_{it} + \beta X_{it} + \delta_i + \theta_t + \varepsilon_{it} \qquad (1)$$

where $ACSC_{it}$ is the hospitalisation rate for ACSCs in the municipality i at year t. $PMAQ_{it}$ is the percentage of FHTs participating in PMAQ. X_{it} is a vector of covariates that capture time-varying characteristics of municipality i at year t. δ_i is the municipality FE, which account for time-invariant characteristics that could affect the hospitalisation rates. θ_t is the year FE and captures any time-specific shock. ε_{it} is the error term. Standard errors were clustered at the level of municipality.

FE estimates account for time invariant unobserved heterogeneity and omitted variable bias, and hence are more appropriate for programme evaluation than random effects (RE) estimates.[40] Hausman specification test[41] was also performed to test whether there is a systematic difference between FE and RE estimates. The null hypothesis was rejected, indicating that FE is preferable to RE.

Sensitivity analyses

We performed several sensitivity analyses. First, we estimated equation (1) by age group and most frequent causes of ACSCs. Second, we also included 'unsatisfactory' or 'declassified' teams in PMAQ participating teams, that is, the numerator of exposure variable (PMAQ) increased. Although these teams were not fully exposed to the incentive scheme, they adhered at the beginning of the PMAQ round. Third, we used a dummy to define PMAQ exposure (=1 if at least one team have participated in PMAQ). Fourth, we used the crude hospitalisation rate for ACSCs instead of the adjusted rate, conducting the same analysis for overall and adult hospitalisations. Fifth, we estimated our main model, equation (1), using the negative binomial distribution. Finally, we performed a placebo test to support the validity of our empirical strategy. Placebo test was conducted using the hospitalisation rate for transport accident (ICD-10 codes: V01–V99).

Patient and public involvement statement

Patients and public were not directly involved in this research. We used publicly available data.

RESULTS

Since its implementation, PMAQ expanded rapidly, reaching on average 50.1% of the FHTs in the first round (2011–2012), 75.7% in the second round (2013–2015) and 86.9% in the third round (2016–2018), not considering teams classified as unsatisfactory or declassified. In 2018, 95.6% of the Brazilian municipalities had at least one FHT enrolled in PMAQ (table 1).

The average adjusted hospitalisation rate for ACSCs for population 0–64 years old decreased by 26.8% (from 127.9 per 10 000 population in 2009 to 93.6 per 10 000 in 2018). Considering the most frequent causes of hospitalisations for ACSCs, there was a large reduction in hospitalisation rates due to gastroenteritis for all age groups (ranging from 44.3% to 52.9%). Hospitalisation rates for asthma also showed a large decline over the period (around 54% for both younger groups of age) (figure 1).

Regarding the covariates used in the FE model, only hospital beds has decreased over the period under investigation, a reduction of 14.6% from 2009 to 2018. Although there is some oscillation within the period, the other covariates increased from the base line to 2018 (table 2).

Table 3 presents the association between the percentage of teams enrolled in PMAQ and ACSC rates. All estimates included year dummies and used robust standard errors clustered by municipality. An increase of PMAQ of one percentage point decreased the hospitalisation rate for ACSC by 0.0356 per 10 000 population (aged 0–64 years). Taking the participation in PMAQ of 89.5% of the total teams, this corresponds to a reduction of 3% of the mean hospitalisation rate for ACSC, or approximately 60 829 (95%CI 19 705 to 1 01 879) hospitalisations in 2018. The impact is stronger for children under five (–0.0940 per 10 000 children under 5 years old), representing a reduction of around 11 936 hospitalisations in this age group in 2018.

The estimated coefficients of PMAQ for the most frequent causes of hospitalisations for ACSCs by age group are presented in figure 2. Higher levels of team enrolment in PMAQ decreased the hospitalisation rate for gastroenteritis only for 0–4 years. Higher levels of team enrolment in PMAQ was also associated with fewer hospitalisation rate for asthma (0–4 years and 5–19 years) and renal disease (20–64 years). For other diseases,

Table 1 Description of the PMAQ engagement across municipalities and FHTs over the period 2009–2018, Brazil

Year	No of municipalities	No of municipalities enrolled in PMAQ*	No of PMAQ teams	No of PMAQ teams classified as unsatisfactory or declassified	No of family health teams†
2009	5569	0	0	0	30 897
2010	5569	0	0	0	32 242
2011	5569	3965	17 482	644	33 213
2012	5569	3965	17 482	644	33 979
2013	5569	5071	30 522	1008	35 850
2014	5569	5071	30 522	1008	39 753
2015	5569	5071	30 522	1008	41 302
2016	5569	5323	38 864	1820	41 483
2017	5569	5323	38 864	1820	42 896
2018	5569	5323	38 864	1820	43 408

*Municipality has at least one PMAQ team. 'Unsatisfactory' means that teams have not complied with the rules of PMAQ. 'Declassified' complies three situations: (1) teams have asked to be formally removed from the PMAQ or (2) teams have refused to be evaluated by the external evaluation or (3) teams that did not have a dental chair.
†Number of family health teams in December of each year.
FHTs, family health teams; PMAQ, Programme for Improving Primary Care Access and Quality.

PMAQ coefficient was not statistically significant (online supplemental appendix 1).

Our sensitivity analyses included a placebo test to support the validity of our empirical strategy. As a placebo variable, we use hospitalisation rates for transport accidents (0–64 years), which is not expected to be related to access and quality of primary care, and therefore with exposure to PMAQ. As expected, the association between PMAQ and the hospitalisation rate for transport accidents is not statistically significant (online supplemental appendix 2).

Additionally, equation (1) was estimated using an alternative definition of PMAQ. First, we included teams that were assigned as 'unsatisfactory' or 'declassified' by the Ministry of Health (column 2, online supplemental appendix 3), showing similar results as shown in table 2.

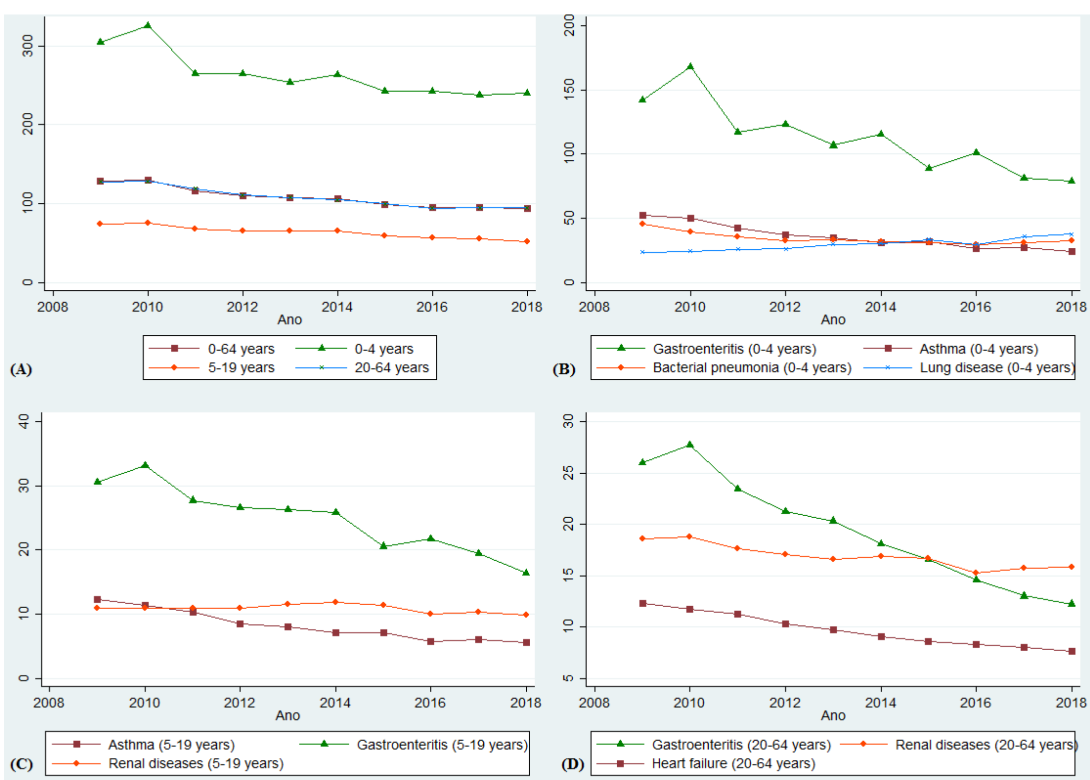

Figure 1 Trends in hospitalisation rates for ACSCs by age group (A) and most frequent causes of ACSCs by specific age group (B–D), 2009–2018, Brazil. ACSCs, ambulatory care sensitive conditions.

Table 2 Descriptive statistics for Brazilian municipalities, 2009–2018

Covariates	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Primary care (%)	86.87	87.60	88.19	88.54	89.97	92.04	92.54	92.22	92.94	92.76
Education (IFDM)	0.66	0.68	0.71	0.72	0.74	0.75	0.76	0.77	0.77	0.78
GDP pc	18 901	19 430	21 392	21 643	22 616	23 463	21 974	22 296	23 328	23 167
Hospital beds	18.30	18.16	17.77	17.41	16.61	16.53	16.17	15.98	15.74	15.62
Population density	109.45	108.19	109.11	109.99	113.99	114.97	115.92	116.87	117.78	118.57

GDP, gross domestic product; IFDM, FIRJAN Index of Municipal Development.

The PMAQ coefficient was −0.0379 (p<0.001) for those aged 0–64 years. Second, we used a dummy to define PMAQ exposure (=1 if at least one team have participated in PMAQ), which showed no statistical significance (column 3, online supplemental appendix 3). Third, we used the crude hospitalisation rate for ACSCs instead of the adjusted rate (column 4, online supplemental appendix 3). PMAQ was associated with a reduction on ACSCs, with a coefficient of −0.0369 (p<0.001) for those aged 0–64 years. Fourth, we estimated equation (1) using the negative binomial distribution (column 4, online supplemental appendix 3). The effect of the variables is expressed as incidence rate ratio (IRR). We found that one unit increase in PMAQ leads to a reduction in the rate of 0.04%. Taking the participation in PMAQ of 89.5% of the total teams in 2018, it represents a reduction of 3.58% in the mean hospitalisation rate for ACSCs. This shows a modest reduction in the hospitalisation rate, as found in our main analyses (table 3).

DISCUSSION

This study found the roll out of PMAQ across municipalities was associated with a modest but significant reduction in avoidable hospitalisations (all ACSCs) for populations aged 0–64 years during the three rounds of the programme (2011–2018). PMAQ was associated with a reduction of around 60 829 (95% CI 19 705 to 101 879) ACSCs for populations aged 0–64 years in 2018. When stratifying by age group and diseases that accounted for a high proportion of ACSCs, PMAQ expansion was associated with a reduction in hospitalisations for gastroenteritis for 0–4 years (−0.048; 95% CI −0.088 to −0.007), asthma for 5–19 years (−0.007; 95% CI −0.013 to −0.002) and renal disease for 20–64 years (−0.010; 95% CI −0.016 to −0.003). Our results are in line with other study carried out in Brazil, which found that PMAQ was associated with a 9% reduction in hospitalisations for ACSCs.[21] We found that an increase of 89.5% of PMAQ participating reduce by 3% of the mean hospitalisation rate for ACSCs. However, our approach differs from their study in some important ways. We use a longer time period, consider the implementation intensity of PMAQ (instead of a dichotomous variable) and control for year dummies. In our sensitivity analyses, the dichotomous measure of exposure became non-statistically significant after including year dummies.

Qualitative studies provide some insights into the potential mechanisms underpinning the effect of PMAQ on avoidable hospitalisations. Previous studies have reported improvements in work processes and planning at the team level. These managerial tools are important to achieve improvements in access and quality of care. For example, home visits, support from other professionals and referral to specialised care when needed have been associated with lower rates of avoidable hospitalisations.[42] In the state of Paraná, workers engaged in PMAQ have reported improvements in health information registries (allowing better monitoring of target populations) and the indicators from the external evaluation provided a good overview of what should be improved at team level.[43] On the other hand, qualitative studies conducted in state of Goiás and São Paulo showed a low perception of the PMAQ impact on clinical practices and work process,[15 44] mainly due to a top-down approach adopted during the implementation of PMAQ, lack of knowledge about the programme and absence of feedback regarding the results of external evaluation. These problems tend to demotivate health worker and consequently jeopardise the access and quality delivered though PMAQ teams.

Other studies have investigated the effect of P4P schemes on ACSCs worldwide. In England, hospitalisation for ACSCs incentivised by QOF reached a reduction of 2.7% (95% CI 1.6% to 3.8%) and 8.0% (95% CI 6.9% to 9.1%) in the first and the seventh year after QOF was introduced, respectively, compared with ACSCs that were not incentivised by the programme.[18] A more recent study conducted in England suggested that QOF was associated with a smaller reduction in incentivised ACSC hospitalisations (IRR 0.993; 95% CI 0.990 to 0.995), where a 1% increase in quality of care corresponds to a decrease of 187 hospitalisations for all incentivised conditions in the period of 2015–2016 at national level.[19]

In Portugal, a difference-in-difference study indicated that municipalities that implemented P4P scheme at FHTs had no statistically significant impact on hospitalisations for ACSCs compared with municipalities that did not implement the scheme.[17] It is worth noting that our study included 19 diseases-related ACSCs, while the English and Portuguese studies included only 8 and 4 diseases-related ACSCs incentivised by its P4P scheme, respectively, and this might have led to a difference in interpretation, as the current study shows a much broader

Table 3 Estimation results for hospitalisation rates for ACSC using fixed effects by age group, 2009–2018, Brazil

	0–64 years	0–4 years	5–19 years	20–64 years
PMAQ	−0.036***	−0.094**	−0.022**	−0.035***
	(−0.060 to −0.012)	(−0.168 to −0.020)	(−0.041 to −0.002)	(−0.061 to −0.010)
Primary care coverage	−0.099***	−0.310***	−0.060**	−0.094***
	(−0.168 to −0.030)	(−0.513 to −0.107)	(−0.115 to −0.005)	(−0.164 to −0.025)
Education index	−15.416	−3.852	−6.222	−14.211
	(−35.762 to 4.930)	(−83.940 to 76.236)	(−22.918 to 10.475)	(−34.893 to 6.470)
GDP pc	−0.000**	−0.000	−0.000***	−0.000**
	(−0.000 to −0.000)	(−0.000 to 0.000)	(−0.000 to −0.000)	(−0.000 to −0.000)
Hospital beds	0.868***	1.233***	0.598***	0.944***
	(0.648 to 1.088)	(0.726 to 1.741)	(0.422 to 0.775)	(0.716 to 1.171)
Population density	0.050***	0.116***	0.027***	0.051***
	(0.033 to 0.068)	(0.070 to 0.162)	(0.019 to 0.036)	(0.027 to 0.076)
d2010	2.125***	21.326***	1.364**	0.813
	(0.820 to 3.430)	(16.516 to 26.135)	(0.121 to 2.608)	(−0.552 to 2.177)
d2011	−8.639***	−33.807***	−3.593***	−6.076***
	(−10.797 to −6.481)	(−40.981 to −26.633)	(−5.472 to −1.715)	(−8.321 to −3.831)
d2012	−14.275***	−33.829***	−6.628***	−13.532***
	(−16.697 to −11.854)	(−41.749 to −25.910)	(−8.687 to −4.569)	(−16.030 to −11.034)
d2013	−14.203***	−40.734***	−4.231***	−14.385***
	(−17.377 to −11.028)	(−51.166 to −30.301)	(−6.887 to −1.576)	(−17.712 to −11.057)
d2014	−16.127***	−31.071***	−4.868***	−17.266***
	(−19.382 to −12.872)	(−41.703 to −20.439)	(−7.565 to −2.171)	(−20.660 to −13.873)
d2015	−22.738***	−51.696***	−10.956***	−21.952***
	(−26.266 to −19.209)	(−63.146 to −40.245)	(−13.844 to −8.068)	(−25.611 to −18.292)
d2016	−25.988***	−49.553***	−13.376***	−26.576***
	(−29.765 to −22.210)	(−61.821 to −37.286)	(−16.463 to −10.289)	(−30.505 to −22.646)
d2017	−26.025***	−55.007***	−13.628***	−26.021***
	(−29.926 to −22.124)	(−67.108 to −42.905)	(−16.863 to −10.393)	(−30.096 to −21.946)
d2018	−26.903***	−52.453***	−17.569***	−25.826***
	(−30.923 to −22.884)	(−64.799 to −40.107)	(−20.797 to −14.340)	(−30.041 to −21.611)
Constant	126.447***	299.922***	70.074***	123.592***
	(110.679 to 142.215)	(242.878 to 356.967)	(57.171 to 82.977)	(107.660 to 139.524)
Observations	55 640	55 640	55 640	55 640
R-squared	0.076	0.032	0.037	0.073
No of id	5564	5564	5564	5564

95% CIs in brackets.
*P<0.1,**P<0.05,***P<0.01.
ACSCs, ambulatory care sensitive conditions; GDP, gross domestic product; PMAQ, Programme for Improving Primary Care Access and Quality.

description of impact of P4P scheme. In the USA, using a propensity score matching of physicians exposed to P4P versus non-exposed to P4P and a difference-in-difference approach at patient level, a study found that two out of three states that implemented P4P schemes had a reduction on ASCS hospital admissions.[20] These results are robust to several regression specifications and matching methods.

Strengths and weaknesses of this study

Although we have not claimed that our results reflect the impact of PMAQ on avoidable hospitalisations, we provided robust estimates of its association on ACSCs. We controlled for confounders at municipality level and we performed several sensitivity analyses. Moreover, we used a rich panel dataset covering all Brazilian municipalities over a 10-year period. Regardless, some limitations

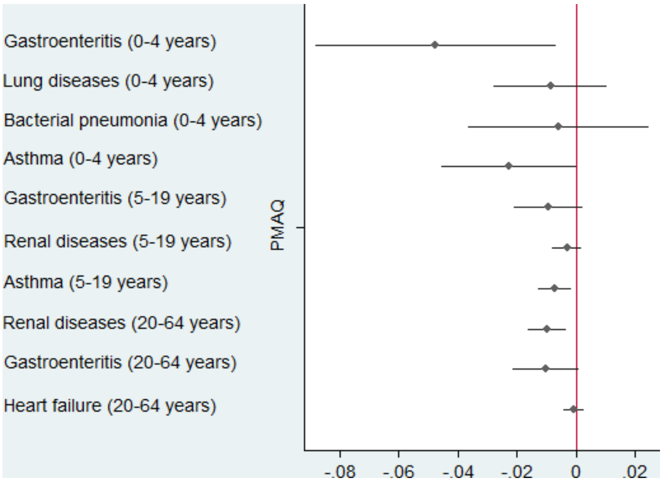

Figure 2 Estimated coefficients of PMAQ for the most frequent causes of hospitalisations for ACSCs by age group, 2009–2018, Brazil. The figure plots the coefficients and CI. ACSCs, ambulatory care sensitive conditions; PMAQ, Programme for Improving Primary Care Access and Quality.

have remained. First, we have treated our exposure as a homogenous variable, but in fact PMAQ can be implemented in different ways at the municipal level. Municipalities decide whether to distribute the PMAQ rewards in kind (training activities, additional drugs and supplies, equipment) or in cash to teams. Second, we used the official Brazilian Ministry of Health list of ACSCs as outcome, which comprised 19 diseases or health conditions. However, not all of them were explicitly incentivised by PMAQ scheme. As a result, our estimates are likely to be conservative. Third, other programmes were implemented in the PHC in the period investigated in this study, such as the More Doctors Programme (Programa Mais Médicos (PMM)). PMM was designed to overcome the insufficiency and turnover of physicians across the country, especially in remote and deprived areas. Studies have shown that PMM was associated with a modest but significant reduction on ACSC hospitalisations[45] and amenable mortality.[46] We have not controlled for PMM because data were not publicly available for the whole period analysed in this study (particularly data from 2018). However, as PMM have increased the supply of physicians across the country, we partially captured its contribution by controlling the PHC coverage.

Implication for policy

Our results suggest that P4P can contribute to improve quality of care at PHC setting, particularly by reducing avoidable hospitalisations. However, caution is needed in any extrapolation of our results to other LMICs. PMAQ has beneficiated from a long period of investment in PHC in Brazil, although this investment was insufficient in view of the health needs of the Brazilian population. The role of FHT has been improved since it was implemented in the mid-1990s, as well as political arrangements for cooperation between municipalities and community participation on health decisions. This context probably provided institutional background to enhance better results of PMAQ.

Moreover, decision-makers must include monitoring and evaluation framework along to health policy implementation to identify expected and unexpected results. It would allow decision-makers to make timely adjustments, avoiding inefficiencies and health inequalities among population groups.

Finally, PMAQ was discontinued by the Brazilian Ministry of Health in December 2019, establishing new bases for PHC funding.[47] Although P4P had remained, it was completely reformulated, replacing hundreds of indicators, external evaluation, and equity concerns by very few indicators (just seven), restricted to few health conditions. Several authors have criticised the new funding of PHC and its impact on access and quality of care.[48 49] Our results can shed some light on the debate on P4P adjustments in the Brazilian context.

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Table S1. The Brazilian list of ambulatory care sensitive conditions (ACSCs) 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*). * Analysis conducted by the authors, crossing the Brazilian list of ACSCs with PMAQ manuals.

Appendix 1 - Estimation results for hospitalization rate for ACSC using fixed effects by age group, 2009-2018, Brazil

	0-4 years				5-19 years			20-64 years		
	Gastroenteritis (34%)	Lung diseases (15%)	Bacterial pneumonia (15%)	Asthma (13%)	Gastroenteritis (32%)	Renal diseases (16%)	Asthma (14%)	Renal diseases (14%)	Gastroenteritis (12%)	Heart failure (10%)
PMAQ	-0.048**	-0.009	-0.006	-0.023*	-0.009	-0.003	-0.007**	-0.010***	-0.010*	-0.001
	[-0.088 to -0.007]	[-0.028 to 0.010]	[-0.036 to 0.025]	[-0.045 to 0.000]	[-0.021 to 0.002]	[-0.008 to 0.002]	[-0.013 to -0.002]	[-0.016 to -0.003]	[-0.022 to 0.001]	[-0.004 to 0.003]
Primary Care Coverage	-0.166***	0.028	-0.075*	-0.048	-0.036**	-0.004	-0.007	-0.013	-0.027*	-0.003
	[-0.276 to -0.056]	[-0.023 to 0.078]	[-0.151 to 0.000]	[-0.111to 0.015]	[-0.066 to -0.005]	[-0.018 to 0.010]	[-0.024 to 0.010]	[-0.033 to 0.007]	[-0.054 to 0.001]	[-0.011 to 0.006]
Education index	-13.629	22.225**	0.768	-37.438***	-4.300	3.700**	-8.289***	2.792	-14.802***	0.785
	[-53.925 to 26.668]	[2.477 to 41.973]	[-22.665 to 24.201]	[-60.423 to -14.454]	[-13.925 to 5.325]	[0.312 to 7.088]	[-14.570 to -2.008]	[-2.126 -to7.710]	[-23.511 to -6.093]	[-1.902 to 3.472]
GDP pc	-0.000	-0.000	-0.000	0.000	-0.000**	-0.000	-0.000*	-0.000	-0.000	-0.000**
	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to -0.000]	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to 0.000]	[-0.000 to -0.000]
Hospital Beds	0.652***	0.020	0.177**	0.284***	0.298***	0.066***	0.093***	0.159***	0.248***	0.075***
	[0.367 to 0.937]	[-0.065 to 0.105]	[0.037 to 0.318]	[0.149 to 0.420]	[0.195 to 0.401]	[0.033 to 0.099]	[0.051 to 0.135]	[0.112 to 0.206]	[0.162 to 0.335]	[0.047 to 0.103]
Population density	0.077***	-0.001	0.018	0.025***	0.018***	-0.001	0.011***	0.004***	0.026***	0.003***
	[0.046 to 0.109]	[-0.015 to 0.013]	[-0.020 to 0.056]	[0.011 to 0.039]	[0.010 to 0.025]	[-0.003 to 0.000]	[0.008 to 0.015]	[0.002 to 0.006]	[0.014 to 0.037]	[0.001 to 0.005]
d2010	26.950***	0.129	-5.955***	-1.626*	2.803***	-0.053	-0.667***	0.104	2.114***	-0.541***
	[23.711 to 30.188]	[-1.024 to 1.282]	[-7.772 to -4.137]	[-3.309 to 0.056]	[2.010 to 3.596]	[-0.391 to 0.284]	[-1.146 to -0.189]	[-0.297 to 0.505]	[1.511 to 2.717]	[-0.811 to -0.271]
d2011	-21.634***	1.818**	-9.429***	-6.894***	-1.915***	0.014	-1.220***	-0.476	-1.199**	-0.898***
	[-25.778 to -17.490]	[0.007 to 3.630]	[-12.319 to -6.539]	[-9.335 to -4.453]	[-3.039 to -0.791]	[-0.451 to 0.479]	[-1.871 to -0.570]	[-1.068 to 0.115]	[-2.170 to -0.228]	[-1.255 to -0.541]
d2012	-14.793***	2.065**	-12.602***	-11.712***	-2.936***	0.118	-2.950***	-1.016***	-3.126***	-1.838***
	[-19.348 to -10.238]	[0.129 to 4.001]	[-15.665 to -9.539]	[-14.211 to -9.212]	[-4.155 to -1.717]	[-0.392 to 0.627]	[-3.636 to -2.265]	[-1.671 to -0.360]	[-4.219 to -2.033]	[-2.221 to -1.456]
d2013	-28.985***	5.078***	-11.458***	-12.126***	-2.571***	0.731**	-2.825***	-1.161***	-3.200***	-2.323***
	[-34.672 to -23.297]	[2.307 to 7.850]	[-15.482 to -7.434]	[-15.303 to -8.949]	[-4.187 to -0.954]	[0.095 to 1.368]	[-3.680 to -1.971]	[-1.983 to -0.339]	[-4.619 to -1.781]	[-2.816 to -1.830]
d2014	-20.224***	5.712***	-12.584***	-16.150***	-2.950***	1.050***	-3.738***	-0.881**	-5.364***	-2.904***
	[-26.207 to -14.240]	[2.907 to 8.516]	[-16.576 to -8.592]	[-19.333 to -12.967]	[-4.558 to -1.342]	[0.400 to 1.700]	[-4.590 to -2.885]	[-1.730 to -0.031]	[-6.775 to -3.952]	[-3.398 to -2.409]
d2015	-46.195***	8.353***	-13.662***	-14.345***	-8.102***	0.521	-3.547***	-1.017**	-6.616***	-3.408***
	[-52.426 to -39.963]	[5.304 to 11.401]	[-17.843 to -9.482]	[-17.806 to -10.883]	[-9.774 to -6.429]	[-0.184 to 1.227]	[-4.479 to -2.614]	[-1.935 to -0.098]	[-8.144 to -5.087]	[-3.918 to -2.899]
d2016	-33.621***	4.351***	-15.333***	-19.522***	-6.798***	-0.725*	-4.815***	-2.307***	-8.263***	-3.525***
	[-40.275 to -26.967]	[1.077 to 7.626]	[-20.108 to -10.558]	[-23.208 to -15.835]	[-8.638 to -4.957]	[-1.468 to 0.018]	[-5.788 to -3.843]	[-3.286 to -1.328]	[-9.944 to -6.583]	[-4.088 to -2.962]

d2017	-53.030***	10.603***	-13.530***	-18.083***	-8.944***	-0.504	-4.529***	-1.857***	-9.709***	-3.704***
	[-59.632 to -46.429]	[7.399 to 13.807]	[-18.298 to -8.761]	[-21.940 to -14.226]	[-10.884 to -7.004]	[-1.272 to 0.264]	[-5.514 to -3.545]	[-2.873 to -0.841]	[-11.411 to -8.007]	[-4.285 to -3.123]
d2018	-55.190***	12.351***	-11.769***	-21.248***	-11.929***	-1.019***	-4.904***	-1.771***	-10.427***	-4.004***
	[-61.879 to -48.500]	[8.918 to 15.783]	[-16.416 to -7.122]	[-25.202 to -17.294]	[-13.817 to -10.040]	[-1.781 to -0.257]	[-5.915 to -3.892]	[-2.802 to -0.739]	[-12.128 to -8.725]	[-4.595 to -3.413]
Constant	145.525***	6.403	46.597***	73.240***	29.706***	7.896***	15.699***	14.765***	30.921***	9.948***
	[116.240 to 174.810]	[-7.886 to 20.691]	[28.702 to 64.492]	[55.956 to 90.524]	[22.235 to 37.176]	[5.303 to 10.489]	[11.022 to 20.376]	[10.938 to 18.591]	[24.303 to 37.538]	[7.922 to 11.975]
Observations	55,640	55,640	55,640	55,640	55,640	55,640	55,640	55,640	55,640	55,640
R-squared	0.079	0.012	0.007	0.034	0.042	0.005	0.032	0.012	0.065	0.041
Number of id	5,564	5,564	5,564	5,564	5,564	5,564	5,564	5,564	5,564	5,564

95% confidence intervals in brackets.

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

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Appendix 2 - Estimation results for hospitalization rate for transport accidents using fixed effects, 0-64 years old, 2009-2018, Brazil

	0-64 years
PMAQ	0.0003
	[-0.003 to 0.003]
Primary Care Coverage	-0.004
	[-0.012 to 0.004]
Education index	0.521
	[-1.941 to 2.984]
GDP pc	0.000
	[-0.000 to 0.000]
Hospital Beds	0.031***
	[0.013 to 0.049]
Population density	-0.007***
	[-0.010 to -0.004]
d2010	1.591***
	[1.414 to 1.767]
d2011	1.942***
	[1.671 to 2.213]
d2012	2.601***
	[2.295 to 2.906]
d2013	3.319***
	[2.911 to 3.728]
d2014	4.223***
	[3.807 to 4.640]
d2015	4.731***
	[4.294 to 5.169]
d2016	5.068***
	[4.594 to 5.541]
d2017	4.890***
	[4.423 to 5.358]
d2018	4.803***
	[4.329 to 5.277]
Constant	6.160***
	[4.329 to 7.991]
Observations	55,640
R-squared	0.061
Number of id	5,564

95% confidence intervals in brackets.
*** p<0.01, ** p<0.05, * p<0.1

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Appendix 3 - Sensitivity analyses

	0-64 years			
PMAQ			-0.037***	0.9996***
			[-0.061 to -0.013]	[0.9995 - 0.9996]
All PMAQ teams	-0.038***			
	[-0.062 to -0.013]			
PMAQ (dummy)		-1.409		
		[-3.760 to 0.942]		
Primary Care Coverage	-0.100***	-0.089**	-0.103***	0.998***
	[-0.169 to -0.031]	[-0.159 to -0.020]	[-0.172 to -0.034]	[0.9976 - 0.9983]
Education index	-15.438	-15.923	-17.761*	2.206***
	[-35.786 to 4.910]	[-36.260 to 4.414]	[-37.975 to 2.453]	[2.0510 - 2.3741]
GDP pc	-0.000**	-0.000**	-0.000**	1.000***
	[-0.000 to -0.000]	[-0.000 to -0.000]	[-0.000 to -0.000]	[1.0000 - 1.0000]
Hospital Beds	0.868***	0.869***	0.876***	1.004***
	[0.648 to 1.088]	[0.648 to 1.089]	[0.658 to 1.095]	[1.0023 - 1.0031]
Population density	0.050***	0.051***	0.054***	1.003***
	[0.033 to 0.068]	[0.034 to 0.068]	[0.035 to 0.073]	[1.0005 - 1.0006]
d2010	2.127***	2.130***	2.765***	0.977***
	[0.822 to 3.432]	[0.825 to 3.436]	[1.449 to 4.081]	[0.9748 - 0.9993]
d2011	-8.426***	-9.458***	-6.810***	0.895***
	[-10.642 to -6.209]	[-11.810 to -7.105]	[-8.975 to -4.646]	[0.8831 - 0.9091]
d2012	-14.064***	-15.061***	-13.061***	0.845***
	[-16.535 to -11.593]	[-17.671 to -12.451]	[-15.485 to -10.638]	[0.8330 - 0.8578]
d2013	-13.923***	-15.826***	-13.861***	0.812***
	[-17.164 to -10.682]	[-19.025 to -12.627]	[-17.050 to -10.672]	[0.7988 - 0.8272]
d2014	-15.868***	-17.588***	-15.518***	0.795***
	[-19.185 to -12.551]	[-20.892 to -14.284]	[-18.781 to -12.255]	[0.7816 - 0.8091]
d2015	-22.485***	-24.137***	-21.970***	0.740***
	[-26.063 to -18.908]	[-27.698 to -20.576]	[-25.507 to -18.432]	[0.7270 - 0.7533]
d2016	-25.717***	-27.873***	-25.311***	0.719***
	[-29.557 to -21.878]	[-31.584 to -24.162]	[-29.103 to -21.518]	[0.7050 - 0.7325]
d2017	-25.762***	-27.855***	-26.669***	0.716***
	[-29.720 to -21.803]	[-31.732 to -23.978]	[-30.577 to -22.761]	[0.7028 - 0.7303]
d2018	-26.644***	-28.689***	-27.661***	0.707***
	[-30.702 to -22.586]	[-32.686 to -24.691]	[-31.686 to -23.636]	[0.6939 - 0.7212]
Constant	126.487***	125.834***	128.830***	5.904***
	[110.719 to 142.256]	[110.026 to 141.642]	[113.142 to 144.518]	[5.5709 - 6.2574]
Observations	55,640	55,640	55,640	55,640
R-squared	0.076	0.075	0.080	
Number of id	5,564	5,564	5,564	5,564

95% confidence intervals in brackets.
*** p<0.01, ** p<0.05, * p<0.1

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