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Title

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Journal

Canadian Journal of Public Health, 110(6)

ISSN

0008-4263

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Publication Date

2019-12-01

DOI

10.17269/s41997-019-00246-9

Peer reviewed



What is the relative impact of primary health care quality and conditional cash transfer program in child mortality?

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Received: 21 August 2018 / Accepted: 4 July 2019 / Published online: 29 July 2019
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Abstract

Objective Evaluate how coverage and quality of primary health care (PHC) and a conditional cash transfer (CCT) program associate with child mortality in Brazil.

Methods Multivariate linear regression models and least absolute shrinkage and selection estimator (LASSO) were utilized with the municipal level child mortality rate as the key dependent variable. PHC quality with PHC and CCT coverage were the independent variables. The quality of the Brazilian PHC was assessed using the Brazilian National Program for Access and Quality Improvement in PHC data. PHC and CCT coverage were calculated based on Brazilian official databases. Human developmental index (HDI), municipality size, and country region were used as control variables. A total of 3441 municipalities were evaluated.

Results We found that ESF (Estratégia Saúde da Família) quality variables PLANNING [Family Health Team Planning activities], CITYSUPPORT [municipality support for Family Health Strategy activities], EXAMS [exams offered and priority groups seen by the family health team], and PRENATAL [prenatal care and exams provided by the family health team], as well as HDI, percentage of PHC coverage, percentage of CCT coverage, and population size have significant and negative relationships with 1-year-old child mortality. LASSO regression results confirmed these associations. Quality is an important element of effective social service provision.

Conclusion This exploration represents one of the first investigations into the role of PHC system quality, and how it is related to health outcomes, while also considering PHC and conditional cash transfer program coverage. Quality of PHC, measured by work process variables, plays an important role in child mortality. Efforts on PHC quality and coverage, as well as on CCT program coverage, are important to child mortality reduction. Therefore, this is an important finding to other PHC public health services.

Electronic supplementary material The online version of this article (<https://doi.org/10.17269/s41997-019-00246-9>) contains supplementary material, which is available to authorized users.

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Résumé

Objectif Évaluer comment la couverture et la qualité des soins de santé primaires (SSP) et d'un programme de transferts monétaires conditionnels (TMC) sont associées à la mortalité infantile au Brésil.

Méthodes Des modèles de régression linéaire multivariée et un estimateur du retrait et de la sélection du moins absolu (LASSO) ont été utilisés, le taux de mortalité infantile au niveau municipal étant la principale variable dépendante. La qualité des SSP avec couverture de SSP et de TMC constituait les variables indépendantes. La qualité des SSP brésiliens a été évaluée à l'aide du programme national brésilien d'accès et d'amélioration de la qualité des données sur les SSP. La couverture en SSP et TMC a été calculée à partir des bases des données officielles brésiliennes. L'indice de développement humain (IDH), la taille de la municipalité et la région du pays ont été utilisés comme variables de contrôle. Un total de 3 441 municipalités ont été évaluées.

Résultats Nous avons constaté que les variables de qualité du FSE PLANNING [activités de planification d'équipe de santé familiale], CITYSUPPORT [soutien des municipalités aux activités de stratégie de santé familiale], EXAMS [examens proposés et groupes prioritaires vus par l'équipe de santé familiale] et PRENATAL [soins prénatals et examens fournis par l'équipe de santé familiale], ainsi que l'IDH, le pourcentage de couverture en soins de santé primaires, le pourcentage de couverture en TMC et la taille de la population ont des relations significatives et négatives avec la mortalité infantile d'un an. Les résultats de la régression LASSO ont confirmé ces associations. La qualité est un élément important de la prestation efficace de services sociaux.

Conclusion Cette exploration constitue l'une des premières enquêtes sur le rôle de la qualité du système de SSP et son lien avec les résultats pour la santé, tout en prenant en compte la couverture des SSP et des programmes de transferts monétaires conditionnels. La qualité des SSP, mesurée par les variables du processus de travail, joue un rôle important dans la mortalité infantile. Les efforts sur la qualité et la couverture des SSP, ainsi que sur la couverture du programme TMC, sont importants pour la réduction de la mortalité infantile. Il s'agit donc d'une découverte importante pour les autres services de santé publique des SSP.

Keywords Primary health care · Quality of health care · Conditional cash transfer program · Child mortality

Mots-clés Soins de santé primaires · Qualité des soins de santé · Programme de transferts monétaires conditionnels · Mortalité infantile

Introduction

Child mortality continues to be a public health problem in Brazil (Victora et al. 2011; Landmann-Szwarcwald and Macinko 2016) in spite of national efforts to improve health. The Brazilian Universal Health Care System was created in 1988, with the implementation of its primary health care (PHC), the Family Health Program (*Estratégia Saúde da Família*-ESF) in 1994. The ESF program provides a broad range of services delivered by a multidisciplinary team that is comprised of a physician, a nurse, a nursing assistant, a dentist, a dental assistant, and community health workers (Ministério da Saúde 2001). Each team is assigned to a geographical area of approximately 4000 participants and is consequently responsible for the health of the population living in this area by providing PHC services (Ministério da Saúde 2012a, b), and making referrals to other levels of care, as required. The health professional teams are intended to work under the aegis of PHC principles, providing basic health care, promoting health activities, and preventing diseases. As of January 2017, there were 39,709 Family Health Teams (FHT) covering 97% ($n = 5398$) of municipalities in Brazil, which corresponds to 63% (approximately 122 million) of the population (Brasil 2017). FHT services are public (free

of charge for the general population). Some financial support comes from the federal government; however, its management is at the municipal level, integrated with other services provided by the city.

The conditional cash transfer (CCT) program *Programa Bolsa Família* (PBF) was created in 2003 to alleviate poverty and diminish health inequalities. It consolidated some earlier social safety net programs, which started as early as 1997 (e.g., School program, Gas program, Food program). It aimed to support socio-economically vulnerable families (Moysés et al. 2008) by breaking the cycle of poverty and extreme poverty. Financial benefits are conditional upon school attendance for older children (at least 75% of school year) (Estrella and Ribeiro 2008), while younger children are required to fully adhere to vaccination schedules and regular health check-ups with the ESF (Ministério do Desenvolvimento Social e Combate à Fome 2014). Requirements for pregnant women include adherence to prenatal care at the Public PHC facilities.

In 2011, the Brazilian government created the National Program for Access and Quality Improvement in Primary Health Care (*Programa Nacional de Melhoria do Acesso e da Qualidade da Atenção Básica*—PMAQ) with the belief that continued evaluation strategy of the ESF is

necessary to improve health care quality. PMAQ evaluation aspect is based on Donabedian's triad, a theoretical framework that systematically evaluates structure, process, and outcomes (Donabedian 1988; Donabedian 2003). The program is based on the establishment of a continuous cycle of improvement of access and quality, divided into four stages: 1st stage, adhesion/contracting (when FHTs seek participation in the program and contract goals with the federal government); 2nd stage, development (strategies intended to promote change in the management, care, and care management, leading to permanent and progressive pursuit of increasing access and quality of care practices and health management); 3rd stage, external evaluation (universities and research centres visit and interview enrolled FHT to collect data related to work process and structure); 4th stage, monitoring and re-contracting (the results of the agreed goals are monitored and the government re-contracts with each FHT based on their outcomes/evaluations) (Brasil 2011). It is noteworthy that during contracting, the municipalities receive financial aid, which could be used during the development stage to achieve the necessary improvements. Upon re-contracting, this financial aid is reassessed and the municipalities may receive more or less funding depending on how their FHTs performed, where better performance provides higher values. In 2012, 3965 of the country's municipalities (71.2%) participated in the program with a total of 17,482 FHT (at the time, 53.1%). PMAQ is the most complete data set of the quality of Brazil's primary health care system, the largest public PHC system in the world.

Studies have shown that the Brazilian CCT and its ESF expansion (Rasella et al. 2013; Paes-Sousa et al. 2011) have a negative and cumulative effect on child mortality. However, how aspects of ESF quality moderate outcomes has not yet been studied. This is likely because process of evaluating the quality of health care programs is exceptionally complex due to the intricacies and range of variables involved in delivering reliable, consistent, and accessible health care. Yet as more countries and international agencies begin to recognize high-quality health care as the cornerstone of socio-economic progress, an increasing number of tools are being developed to measure the impact and effectiveness of health care policies and practices (Shi 2012; Bitton et al. 2016; Macarayan et al. 2018). PMAQ is one of the largest evaluations of its type and thus can provide valuable insight for future projects.

There are numerous CCT programs already in place around the world (e.g., Mexico, Nicaragua, Honduras, Colombia, Chile, Malawi, Ghana, Nepal, Tanzania) (Ranganathan and Lagarde 2012). Several studies worldwide have demonstrated that conditional cash transfer

programs positively impact children's health through two pathways: (1) through increased use of preventive services, immunization coverage, and promotion of healthy behaviour change (Lagarde et al. 2009; Garrder et al. 2010; Ranganathan and Lagarde 2012; Adato et al. 2011) and (2) through the effect of increased income for extremely poor families (Rasella et al. 2013; Fernald et al. 2008). However, CCT programs have been criticized because provision of incentives for individuals to change behaviour might not work without supply side investments (Forde et al. 2011), such as a good health care system. According to Fernald (2013), CCT in countries without nationalized health care might not be as effective. It might then be inferred that in countries where the national health care system is not working at its full potential, the effectiveness of CCT and the generation of social/human capital might not be fulfilled, which in turn support the necessity of nation-wide health system implementation and evaluation. We add to the literature by taking some aspects of health quality provision into account. As mentioned before, studies have evaluated the effect of the Brazilian CCT and its ESF expansion on child mortality and health (Rasella 2013; Paes-Sousa et al. 2011) and have shown that those policies have a positive and cumulative effect. However, to date, no one has ever investigated the impact of ESF quality on child mortality. Therefore, the purpose of the current study was to evaluate how these policies influence health outcomes in the population. More specifically, we aim to answer how PBF coverage and ESF coverage and aspects of work process quality (measured by PMAQ) affect child mortality.

Materials and methods

This study has an ecological design using multiple groups, with the municipality as the unit of analysis. A dataset was created utilizing mortality rate, cash transfer program coverage, primary health care coverage and indicators of primary health care quality human developmental index (HDI), municipality size, and municipality region. From the 5565 Brazilian municipalities, we selected a subset ($N = 3441$) that had adequate statistics on all analyzed variables in 2012.

Data

Dependent variable: child mortality

Child mortality was calculated using live births and child mortality (mortality up to 1 year of age) registries (*Sistema de Informações sobre Nascidos Vivos*) (*Sistema de Informação sobre Mortalidade*) from the Ministry of

Health's Unified Health System Informatics Department (*Departamento de Informática do Sistema Único de Saúde*) (*Departamento de informática do SUS 2015*). Vital statistics data are collected by the State Health Secretariats and reported to the Ministry of Health, where they are subject to quality improvement efforts, and are made publicly available, organized by municipality of residence. Births are tracked by birth certificates, which are recorded in health facilities and in local registry offices (for births occurring outside of a health facility). Similarly, death certificates are completed in health facilities or morgues, or must be signed by a medical doctor and submitted to a notary's office for deaths occurring at home (by law, no burial can take place without the official death certificate). While data are available for as early as 1996, major quality improvements in the data collection were implemented in 2010 (Andrews et al. 2017), which is when the data was used for the current study. We calculate child mortality as the ratio of deaths to births, multiplied by 1000. The log of 1-year-old child rate was used to normalize the data, which was skewed.

Independent variables: coverage and quality of programs

Cash transfer program coverage data were reported by the Brazilian Ministry of Social Development and Fight against Hunger, which is responsible for the PBF implementation in the country (Ministério do Desenvolvimento Social e Combate à Fome 2012). Primary health care coverage (ESF coverage) information was provided by the Brazilian Ministry of Health, more specifically from the PHC department (DAB) of this ministry (Ministério da Saúde 2012a, b). These variables are percentages, indicating which percentage of the population is covered by these programs.

For Donabedian (2003), quality in health is the product of two factors: the science and technology of health care and the application of that science and technology in practice. PMAQ external evaluation questions are based on the Donabedian triad of health system quality—infrastructure, work process, and patients' evaluation of the service (Donabedian 1988; Donabedian 2003). However, for the current study, we focused on the second factor of Donabedian's view of quality, as we believe that the work process characteristics of health workers are related to the way science and technology are applied in the health units. For Donabedian (1988, 2003), the process denotes the transactions between patients and providers throughout the delivery of health care.

We calculated composite indexes (CIs) from variables in the work process module. Though our analysis is only for 2012, we did consider the 2014 PMAQ in creating the indices such that they would be comparable across years for additional studies. We excluded items with more than 5000 missing observations per survey year. Items were then grouped into 10

work process variables based on FHS guidelines (Ministério da Saúde 2001; Ministério da Saúde 2012a, b) and PMAQ axis of evaluation (Brasil 2011). A series of tests validated these recommended groupings: pair correlation, Cronbach's alpha, and factor analysis. Then each item was scaled from 0 to 1 (1 = most positive outcome) and the items within a group averaged to form the CI. Additionally, averaging all the CIs created the overall work process variable. Table 1 describes the CIs with the items from which they were created.

Covariates

As control variables, the model included HDI, municipality size, and country region. HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable, and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. The health dimension is assessed by life expectancy at birth, and the education dimension is measured by mean of years of schooling for adults aged 25 years and more, and expected years of schooling for children of school-entering age. The standard of living dimension is measured by gross national income per capita (United Nations 2017). Data on HDI were gathered from the United Nations Development Programme (UNDP) for the year 2010, the nearest year available to the year of interest—2012 (United Nations 2010). Municipality population and country region (North, Northeast, Midwest, Southeast, and South) data were gathered from the Brazilian Institute of Statistics and Geography (IBGE) for the year 2012 (IBGE 2012).

Municipalities studied

Of the 5565 municipalities in Brazil, 3441 had information regarding 1-year-old mortality rate, HDI, city size, country region, ESF, and PBF coverage. When all covariates are taken into consideration, 2196 (39.5% of all Brazilian municipalities) had data available and were included in our final analysis.

Data analysis

Multivariate linear regression was applied to analyze the data. We fit a number of models with different specifications from our dataset. Always utilizing the logarithm of 1-year-old child mortality rate as the outcome, regression was first completed using percentage of ESF and PBF coverage, as well as HDI, city/municipality size, and region as covariates (model 1). Next we included a vector of ESF work process quality CIs as well as interactions between three of the work process CIs, as these could be seen as a collective approach to health care (child attention [CHILDATTENTION], health attention exams [EXAMS], and prenatal attention

Table 1 List of variables that constituted each composed index (CI) created based on PMAQ external evaluation questions

Composed index name	Brief description of the CI
LINKTOSERVICE	Professional link to the service: stability on job, carrier plan, financial incentives for performance, continuing educational initiatives.
PLANNING (Family Health Strategy planning activities)	Family Health Strategy planning activities: Does the health team perform planning activities?; Is there a monitoring and analysis of health indicators and information?; a self-evaluation process utilized by the team?; Is the patient opinion taken into consideration for the labour process qualification?
CITYSUPPORT	Municipality support for Family Health Strategy activities: The health team receives support/help for planning and for work organization process by the municipality (data information, training, specialized professional help, case discussion)?
WELCOME	<i>Acolhimento</i> /Patient Welcome in the Family Health Strategy: The team performs “ <i>acolhimento</i> ” to spontaneous demand in the health unit?; The team provides service for patient removal/transfer/take to hospital, when necessary?; Does the agenda of the health team is organized to - educational health groups; There is reserve places on the agenda or easy access to professional schedule so patients can search and present/discuss test results or for the patients post-consultation questions or show how their health situation involved?
EXAMS	Exams offered and priority groups seen by the family health team: For which groups does the team offer action - Pregnant women, children, those with diabetes mellitus, etc.; Which exams are performed in the health unit - creatinine, lipid profile, electrocardiogram, glycosylated hemoglobin, smear microscopy for tuberculosis, chest x-ray (tuberculosis), smear for leprosy, mammography.
PRENATAL	Prenatal care and exams provided by the family health team: Which exams are performed in the health network for prenatal care - fasting glucose, syphilis serology (VDRL), HIV serology, serology for hepatitis B, Urine culture or urinalysis; The team feeds monthly the prenatal care information system and utilizes it to monitor pregnant women?; For the pregnancy monitoring, is there information regarding - the professional responsible for the monitoring of pregnant women, dental consultation for pregnant women, pregnant women vaccination status, collection of pap test performed during pregnancy; The team gets the results of pregnant women examinations in time for the necessary interventions?
CHILDATTENTION	Child care provided by the family health team: The team conducts childcare query (<i>puericultura</i>) in children under two years?; Uses the child's health booklet for monitoring the growth and development?; During follow-up of children in the region/area there is - children vaccination, growth and development, nutritional status, newborn screening, family violence, accidents.
HEALTHPROMOTION	Health promotion activities offered by the family health teams to the community: The team offers educational activities and/or health promotion activities directed to - women (cervical and breast cancer), family planning, pregnant and postpartum women (breast-feeding), men; elders, health nutrition, Conduct educational strategies related to sexual and reproductive health, Conduct focus groups to guide on communicable diseases (dengue, tuberculosis, leprosy, HIV, trachoma), as required by the people in the territory; The use and abuse and dependence resulting from the use of crack, alcohol and other drugs, such as anxiolytics and benzodiazepines; The team incentives and develops in the health unit or territory/area - corporal practices and physical activity?
HOMEVISIT	Organization of home visit by the family health team: The team has protocol or criteria for home visits?; The families of the primary care team catchment area visited in distinct frequency according to risk and vulnerability assessments?; The team has survey/mapping of the assigned users who need to receive care at home (including bedridden)?; During home care, the family health professionals do - clinical care (elders or in need of home care and Performing nursing procedures)?
SOCIALPARTICIPATION	Community communication with the family health team: The team offers communication channels that allow users to express their demands, complaints and or suggestions in primary care?; Is there local health council or other spaces of popular participation and or Social control?
SCHOOLHEALTH	School Health Activities performed by the family health team: The team performs activities in the school?; Which clinical activities are performed by the team - update the immunization schedule; early detection of hypertension; neglected health disorders detection; ophthalmologic evaluation; hearing evaluation; nutritional evaluation; oral health evaluation; food safety actions and promoting healthy eating (educational activities on the promotion of nutritional and healthy lifestyles; promotion of corporal practices and physical activity in schools; education for sexual health, reproductive health and STD/AIDS; Actions to prevent the use of alcohol, tobacco and other drugs; training activities for education professionals/teachers to work with health education; Debate/discussion with school teachers; does not carry out actions of promotion and prevention.

[PRENATAL]). A variance inflation factor (VIF) test was performed to evaluate collinearity among variables in the

regression models. We used STATA (version 14.0) for database processing and analysis.

$$\begin{aligned} \text{child mortality rate} = & \alpha + \beta_1\text{ESFcov} + \beta_2\text{PBFcov} \\ & + \beta_3\text{HDI} + \beta_4\text{Region} \\ & + \beta_5\log\text{PopSize} + \varepsilon \end{aligned} \quad (1)$$

$$\begin{aligned} \text{child mortality rate} = & \alpha + \beta_1\text{ESFcov} + \beta_2\text{PBFcov} \\ & + \beta_3\text{HDI} + \beta_4\text{Region} \\ & + \beta_5\log\text{PopSize} + \gamma\text{ESFquality} \\ & + \varepsilon \end{aligned} \quad (2)$$

We also examined the output of the least absolute shrinkage and selection estimator (LASSO) regression (Tibshirani 1996) and as many of the covariates included in our model may have a highly collinear structure. Collinearity produces highly variable estimators for traditional linear regression, but LASSO is known to handle such data structures more effectively in terms of reducing estimator variance. Therefore, a LASSO regression on our full subset of covariates (model 2) was used, together with VIF test, to confirm our coefficient results from the linear regression.

Results

Descriptive values for the CI variables are described in Table 2. It is interesting to note that EXAMS present the highest average value and the lowest variance (low standard deviation value), suggesting that most FHTs are successful in this arena, while the SCHOOLHEALTH variable presents the lowest average value, suggesting much improvement is needed. HEALTHPROMOTION has the highest variance. It is also important to note that dependent, independent, and covariate variables mean values and variability (standard deviation) of the CIs were similar when calculated based on all municipalities available or when utilizing data from the municipalities in the regression model.

In the 1st regression model, ESF coverage and PBF coverage were weakly associated with child mortality, while controlling for HDI, municipality size, and country region (Table 3). Regressions including measures of health centre quality show that PLANNING and CITYSUPPORT are negatively associated with child mortality. SOCIALPARTICIPATION and SCHOOLHEALTH are positively associated with child mortality, when controlling for HDI, municipality size, country region, and percentage of ESF and *Bolsa Familia* coverage (Table 4). Additionally, it can be noted that the variables PLANNING, CITYSUPPORT, HDI, percentage of ESF coverage, percentage of PBF coverage, and population size have significant and negative relationship with 1-year-old child mortality, meaning that the higher their values, the lower the child mortality. On the other hand, SOCIALPARTICIPATION and SCHOOLHEALTH have

a positive relationship with the outcome. The Southeast region, taking the North region as reference, also presents a significant relationship with the outcome investigated. Despite not being significant, PRENATAL ($p=0.062$) and EXAMS ($p=0.054$) possess a negative regression coefficient with the outcome. The strength of the regression coefficients varied substantially among the variables, showing the different associations that they have with the outcome in the context of the considered models. VIF test results confirmed negligible collinearity among the variables utilized in the regression models. Similar results for regression and collinearity are similar to model 2, using 1-year-old mortality, when using 5-year mortality (tables available upon request).

LASSO regression model was also performed and its results closely match those found by the linear regression, confirming the results of regression model 2 (Supplementary Figure 2).

Discussion

Our primary findings were that quality aspects of primary health care play a role, together with other known variables, on the health outcome child mortality. More specifically, we found that PLANNING, CITYSUPPORT, SOCIALPARTICIPATION, SCHOOLHEALTH, HDI, percentage of ESF coverage, percentage of PBF coverage, and population size have a statistically significant association with 1-year-old child mortality.

The PHC quality aspects evaluated in the current study were work process variables. Work process in health can be understood by its three components: the work itself, the work object, that is, the matter to which the work is applied, and the instruments or means of work (Schraiber 1996; Mendes Gonçalves 1979; Mendes Gonçalves 1992; Mendes-Gonçalves 1994; Nogueira 2002). PMAQ data allows the evaluation of aspects that influence its components, such as the planning process, health attention, professional mode of contract, and population involvement. This study seeks to assess which of these aspects have the strongest associations with PHC development in Brazil; thus, they have been included in the analysis.

Another finding was that teams that more comprehensively plan their work activities and that receive better support from the municipalities on this process [PLANNING] (e.g., epidemiological data, expert support) are less likely to experience child mortality. These seem to be important differentials between the FHT with good child mortality outcomes and those with poor child mortality outcomes. These results are also confirmed in the LASSO regression. Examining the coefficient trace plot (Fig. 1) demonstrates that PLANNING [Family Health Team Planning activities] and CITYSUPPORT maintain their positive associations with prevention of child mortality despite more stringent LASSO penalizations. The stability of the coefficient estimates across

Table 2 Descriptive value for work process composed index (CI) created based on PMAQ external evaluation questions in 2012

Variable	Obs	Mean	Std. dev.	Min	Max
1-year-old child mortality rate*	2196	3.699	1.792	.054	8.900
IDHM2010	2196	.660	.074	.418	.862
Population in 2012	2196	10.105	1.091	7.417	16.247
FHT percentage of coverage (primary care) in 2012	2196	80.736	26.014	0	100
<i>Bolsa Familia</i> (CCT program) percentage of coverage in 2012**	2196	106.909	20.397	26.39	208.74
LINKTOSERVICE	2196	.498	.181	0	1
PLANNING	2196	.781	.109	.2	1
CITYSUPPORT	2196	.832	.183	0	1
PATIENTWELCOME	2196	.750	.150	0	1
EXAMS	2196	.929	.086	0	1
PRENATAL	2196	.849	.114	0	1
CHILDATENTION	2196	.727	.163	0	1
HEALTHPROMOTION	2196	.574	.186	0	1
HOMEVISIT	2196	.636	.137	.142	.885
SOCIALPARTICIPATION	2196	.611	.272	0	1
SCHOOLHEALTH	2196	.493	.201	.066	1

*Mortality rate is calculated based on the Log of 1-year mortality rate; **the percentage is calculated based on optimal coverage (one team for 4000 persons); therefore, the results may be over 100%. Variables description/CI descriptions: LINKTOSERVICE [professional link to service] 2012; PLANNING [Family Health Team Planning activities] 2012; CITYSUPPORT [municipality support for Family Health Strategy activities] 2012; PATIENTWELCOME [*Acolhimento*/Patient Welcome in the Family Health Strategy] 2012; EXAMS [exams offered and priority groups seen by the family health team] 2012; PRENATAL [prenatal care and exams provided by the family health team] 2012; CHILDATENTION [child care provided by the family health team] 2012; HEALTHPROMOTION [health promotion activities offered by the family health teams to the community] 2012; HOMEVISIT [organization of home visit by the family health team] 2012; SOCIALPARTICIPATION [community communication with the family health team] 2012; SCHOOLHEALTH [School Health Activities performed by the family health team] 2012

different penalties is promising. First, this means that the relationships that PLANNING [Family Health Team Planning activities] and CITYSUPPORT have with child mortality

outcomes are stable even when the covariates considered in the model are changed. Second, PLANNING and CITYSUPPORT are important predictors, in the machine

Table 3 Model 1 regression results. These are the results from the regression run in STATA using robust standard error estimation

Linear regression		Number of obs=	3441		
		$F(83, 3432)=$	153.15		
		Prob> $F=$	0.0000		
		R -squared=	0.2495		
		Root MSE=	15.719		
1-year-old child mortality	Coef.	Robust std. err	t	p value	
HDI 2010	−.262.729	.5594122	−4.70	0.000	
Population in 2012	−.8117571	.0340241	−23.86	0.000	
Region (North)					
2 (Northeast)	.3509177	.08943	3.92	0.000	
3 (Southeast)	.3019944	.1133418	2.66	0.008	
4 (South)	−.2572473	.1261191	−2.04	0.041	
5 (Midwest)	−.1242126	.1305167	−0.95	0.341	
FHT percentage of coverage (primary care) in 2012	−.0032158	.0011379	−2.83	0.005	
<i>Bolsa Familia</i> (CCT program) percentage of coverage in 2012	−.0054014	.0014216	−3.80	0.000	
Cons	1.427.816	.4380323	32.60	0.000	

Table 4 Model 2 regression results. These are the results from the regression run in STATA using robust standard error estimation

Linear regression		Number of obs=	2196		
		<i>F</i> (22, 2173)=	47.15		
		Prob> <i>F</i> =	0.0000		
		<i>R</i> -squared=	0.2957		
		Root MSE=	1.5123		
1-year-old child mortality	Coef.	Robust std. err	<i>t</i>	<i>p</i> value	
HDI 2010	− 4.837.107	.7184304	− 6.73	0.000	
Population in 2012	− .7302471	.0415135	− 17.59	0.000	
Region 1 (North)					
2 (Northeast)	.193598	.1209242	1.60	0.110	
3 (Southeast)	.3005348	.1427574	2.11	0.035	
4 (South)	− .1489768	.1574138	− 0.95	0.344	
5 (Midwest)	− .0379396	.1627962	− 0.23	0.816	
FHT percentage of coverage (primary care) in 2012	− .0033924	.0015565	− 2.18	0.029	
<i>Bolsa Familia</i> (CCT program) percentage of coverage in 2012	− .0060908	.0017135	− 3.55	0.000	
LINKTOSERVICE 2012	− .1531533	.1895478	− 0.81	0.419	
PLANNING 2012	− .8340969	.4107607	− 2.03	0.042	
CITYSUPPORT 2012	− .8733631	.2268884	− 3.85	0.000	
WELCOME 2012	.0552164	.260737	0.21	0.832	
EXAMS 2012	− 2.74038	1.422804	− 1.93	0.054	
PRENATAL 2012	− 3.392439	1.819698	− 1.86	0.062	
CHILDATENTION 2012	.7916738	1.666155	0.48	0.635	
HEALTHPROMOTION 2012	− .1916463	.2271579	− 0.84	0.399	
HOMEVISIT 2012	.2808219	.3200737	0.88	0.380	
SOCIALPARTICIPATION 2012	.3012046	.1360498	2.21	0.027	
SCHOOLHEALTH 2012	.4710821	.1996605	2.36	0.018	
int_HEALTH_PRENATAL 2012	5.270.301	1.959186	2.69	0.007	
int_HEALTH_CHILD_2012	.2555862	1.901962	0.13	0.893	
int_CHILD_PRENATAL_2012	− .8702032	1.204815	− 0.72	0.470	
Cons	17.04.386	1.34032	12.72	0.000	

Variables description/CI descriptions: LINKTOSERVICE [professional link to service] 2012; PLANNING [Family Health Team Planning activities] 2012; CITYSUPPORT [municipality support for Family Health Strategy activities] 2012; WELCOME [*Acolhimento*/Patient Welcome in the Family Health Strategy] 2012; EXAMS [exams offered and priority groups seen by the family health team] 2012; PRENATAL [prenatal care and exams provided by the family health team] 2012; CHILDATENTION [child care provided by the family health team] 2012; HEALTHPROMOTION [health promotion activities offered by the family health teams to the community] 2012; HOMEVISIT [organization of home visit by the family health team] 2012; SOCIALPARTICIPATION [community communication with the family health team] 2012; SCHOOLHEALTH [School Health Activities performed by the family health team] 2012

learning sense, that should be included when trying to find a smaller subset of covariates that adequately predict child mortality. Corroborating with this finding, Hone et al. (2017) showed that mortality reductions associated with primary care expansion were greatest in municipalities with strong governance. These findings suggest that strengthening local health governance may be vital for improving both service effectiveness and health outcomes in decentralized health systems, which are a reality in other countries around the globe.

Findings of our study presented planning as being one of the ESF work process quality variables with a higher

relationship (coefficient) with child mortality rate, showing the importance that planning has in the work process of a family health team that is concerned with health outcomes. Planning, as a process of thinking about and organizing activities required to achieve a desired goal, also favours the monitoring and evaluation of implemented actions, subsidizing the decision-making for reordering or maintenance of actions. Planning processes that are democratically constructed and agreed upon among the actors involved are more effective because they are better aligned with local needs and realities. They also favour

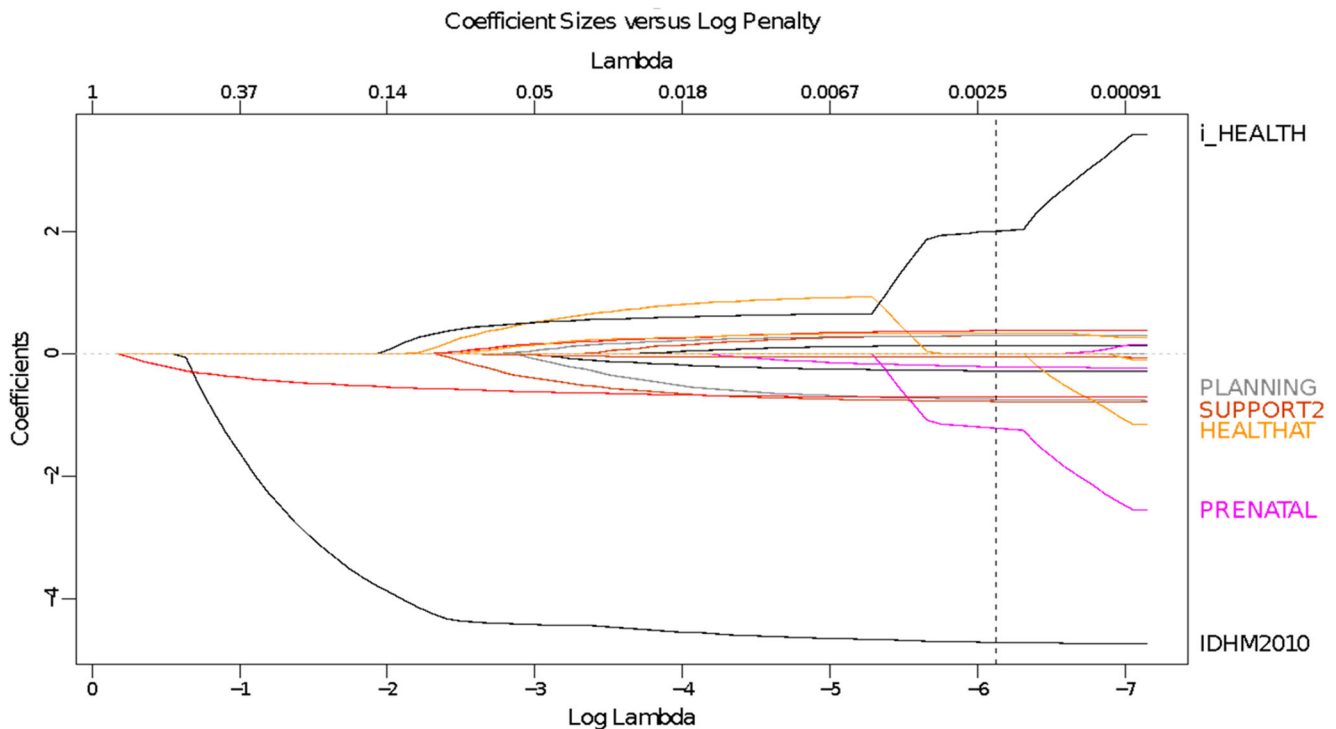


Fig. 1 LASSO coefficient trace plot versus penalty size. The image presents the coefficient sizes across the varying penalties, with the optimal penalty represented by the vertical dashed line. In this plot, the x -axis traces the penalty size from most restrictive on the left to least restrictive on the right. Therefore, the coefficient sizes on the right side of the plot (when there is no penalty) should match the coefficient estimates found using ordinary least squares estimation. As the penalty increases, the coefficients “shrink” towards zero. In the most extreme setting, when the logged penalty is 0, all coefficients shrink to zero. The coefficients identified on the right-hand side of the plot are those that are furthest from zero. The vertical dashed line marks the optimal penalty ($\lambda = 0.00218984$). It is clear that even near the most restrictive penalty, População2012 (not labeled) and HDI2010 (IDHM2010) have

high predictive power in predicting child mortality within the first year. In fact, PLANNING2012, CITYSUPPORT2012, logpop2012 (logarithm of the municipality population size), and HDI2010 (IDHM2010) all linger in the model with a similar trend: high scores in these areas are associated with lower child mortality. The interaction term between EXAMS2012 (HEALTHAT) and PRENATAL2012 (indicated here by i_HEALTH) appears to linger in the model with the opposite association, but is not nearly as consistent in its coefficient estimation as many of the other variables. The coefficient EXAMS2012 (HEALTHAT) appears to be rather instable with respect to the other covariates included in the model. At our optimal penalty, the coefficient on EXAMS2012 is set to zero. This seems reasonable as its coefficient estimate appears to be positive or negative depending on what else is in the model

greater communication among the actors, with an increase in managerial capacity for decision-making and collective awareness and accountability of those involved (MATUS 2000). From the author’s best knowledge, this is the first time that such a variable (PLANNING [Family Health Team Planning activities]) is so clearly linked with population health outcomes. The PNAB (Ministério da Saúde 2012a, b) points out that the FHT should plan their action according to the community necessity, preferably based on the population needs and through a democratic and participative manner. Additionally, it mentions that the FHT should systematically monitor and evaluate the actions implemented, aiming at the readjustment of the work process. However, professional motivation and government pressure have been insufficient to explore the potential for this type of action (Petrola et al. 2016), where FHTs seem to prioritize nationwide directions/programs from the Ministry of Health, rather than organizing the service based on local community need. Good planning

needs time and involvement of the team and should be valued by the municipalities. The questions regarding this variable are related to the planning of the health team as a whole (relative macro perspective), but also the opportunity for individuals/family treatment planning (micro perspective), looking from the data organization of patients records through to the community monitoring and analysis of health indicators and information (for the community under the care of the FHT). The CITYSUPPORT variable is, in a certain manner, related to the municipality involvement in the planning support. The right support provides a fertile environment for FHT planning and therefore, for good community health outcomes.

The current study sheds light on the planning aspect of the FHT work process (PLANNING) as well as the municipality support (CITYSUPPORT) on this process. Quite commonly these aspects are relegated to a second level of importance, as the treatment, the prescription, and the medication are seen as the priority. For some, no time can be removed from patient’s

care towards planning as this is seen as “a waste of time.” Nevertheless, our data point to the importance of those variables, suggesting that the planning process, supported by the municipality, allows the FHT to work more efficiently and, therefore, bring important benefits to the community health outcomes. We hope that this paper brings awareness to this fact, and that planning becomes a constant and a priority in PHC.

Despite not being significant at the 5% level in the linear regression, prenatal care (PRENATAL) presents a high and negative regression coefficient. However, when considering a 10% significance cut off, the model supports that better prenatal care is associated with lower child mortality rates. Understanding that the highest percentage of child mortality occurs in the first month, and important causes of child deaths can be avoided with good quality prenatal care, this finding reinforces the necessity of continued improvement on the quality of prenatal care in order to prevent child mortality. The LASSO regression appears to pick up on this relationship more efficiently. After HDI, the coefficient assigned to PRENATAL is the largest protective coefficient out of all of the covariates considered. Examining the coefficient trace plot (Fig. 1), it does appear that there is some relative instability of this coefficient estimate, which may help explain why it is insignificant in the linear regression models. Nevertheless, the coefficient estimated on PRENATAL appears to always be protective with respect to child mortality, but depends heavily on the other covariates included in the model.

It is not clear why social participation (SOCIALPARTICIPATION) and school health (SCHOOLHEALTH) activities have a negative association with 1-year-old child mortality. According to Fig. 1, these coefficients (not labeled) do appear to be stable in their negative impact for LASSO evaluation. It is possible that social participation and health promotion in school activities may compete for the FHT time. However, with the available data, this possibility cannot be tested or proven.

It can be noted that, as expected from previous work, the population size, municipality region, HDI, and percentage of PBF and ESF coverage are all related to child mortality. Hence, the data set created by adding information from different sources is consistent with previous known knowledge and representative of the reality in the country (Rasella et al. 2013; Aquino et al. 2009; Rasella et al. 2014; Rasella et al. 2010; Paes-Sousa and Quiroga 2011; Paes-Sousa et al. 2011). What the current work adds to the previous knowledge is that the quality of the primary health care, measured by work process variables, does play an important role on child mortality.

It was interesting to find the regression coefficients regarding the PBF and ESF percentage of coverage were only marginally statistically significant in the analysis. This may be due to the low variability of coverage in the municipalities involved in the analysis. It is interesting to point out that these

policies (PBF and ESF) are well implemented in the country. The percentage of coverage of PBF is above 90% on 80% of the municipalities studied, while for ESF coverage, 70% of the municipalities possessed more than 80% of ESF coverage. Once again, we add to the previous knowledge by demonstrating the importance of service quality (ESF work process quality) on child mortality, once policy coverage has been achieved. This is an important finding to all PHC public health services around the world, as the quality insurance of these services may improve their impact on the population health indicators, which is the aim of their existence.

As mentioned before, considering the possible interactions among three of the work process CIs, as they could be seen as a collective approach to health care (child, health, and prenatal attention), the interactions among them were evaluated. The only significant interaction was found between health and prenatal attention CIs. Nevertheless, all interactions were kept in the regression model due to the understanding that the conceptual framework informing the interaction among the three selected variables, as they could be seen as a collective approach to health care, being the clinical attention outcomes evaluated by PMAQ and representative of what is performed by the FHT on their clinical time. It is important to note that, in the initial model, without the interaction terms, all of the coefficients represent the unique effect or main effect when considering the other covariates in the model. In the model with the interaction terms (which is a conditional effect), the independent predictors no longer indicate unique or main effects; they now indicate conditional effects on the other variable in the interaction term that they are a part of being equal to zero.

This study has limitations, especially related to the ecological study design which utilizes secondary data with potential collinear variables. Data reliability is always a concern in this type of study and has a potential for bias, despite our effort to utilize the best available data sources. The data were not collected for the purpose of the current study, and therefore, certain hypotheses and/or paths of causality could not be studied. These data are not causal in nature and there could be additional factors correlated with the variables and the error term. Missing variables, although not linear among the municipalities, was a common finding on the data set. Since regression was only performed when all variables were available for the municipality, once again means there is a potential for bias, which is an important limitation. Nevertheless, municipalities from all regions, different size (population), and varying IDH and work process CI variables allowed us to investigate which aspects/variables play a role on 1-year child mortality. Despite not utilizing data from all municipalities in the regression models, as they were not available for the study, the similarities found among the data mean values and variability, when comparing all data available and data on the municipalities utilized in the regression model, one can be sufficiently confident of how robust the finding of the study is.

Nevertheless, it is important to notice that child mortality rate is not solely determined by the health care system. The family is also a large contributor to health. We cannot determine the extent to which the family has successfully received and incorporated the health team's preventive suggestions or indications about when to bring in an ill child. If the child is brought to medical attention too late, even the best quality team may fail.

Brazil is not unique among developing countries in facing challenges in reducing infant mortality. Many developing countries are investing in family health clinics and primary care as low-cost interventions for improving the health of their populations. While the structure may not be the same as Brazil's primary health care, through its Family Health Teams, the issues they face are similar, such as limited supply of medicine and working in teams. Thus, these results are important for highlighting which areas of quality may be most promising for improving child mortality in other locations beyond Brazil.

Our findings add to the existing literature because this exploration represents one of the first investigations into the role of primary health care system quality, and how it is related to health outcomes, while also considering PHC and conditional cash transfer program coverage. In the last decade, a series of studies have evaluated the impact of ESF and CCT in health indicators, including child mortality (Aquino et al. 2009; Rasella et al. 2010; Rasella et al. 2014). However, the quality of primary health care was never in the model of analysis. Our paper indicates that quality is an important element of effective social service provision.

Conclusion

Overall country development, as represented here by HDI, will remain the strongest force in determining Brazil's progress towards better health outcomes for its population, including the prevention of child mortality within 1 year of life. However, intervening on more proximal aspects of the national health system may see short-term gains. Therefore, efforts on ESF quality and coverage, as well as PBF coverage, are important to child mortality reduction. By focusing on the sustainable implementation of improved support for FHTs to plan and provide more comprehensive care as well as increased quality and accessibility to prenatal services for women, Brazil may find itself on a trajectory towards reduced child mortality.

Compliance with ethical standards

Conflict of interest Authors APGFVM, MSAD, MIOV, ESCR, AMBA, and MFASM were involved on data collection of PMAQ, the external evaluation on the state of Ceará. Author TXAP was involved on data

collection of PMAQ external evaluation on the states of Ceará and Rio Grande do Norte. The manuscript utilizes, as one of the sources, a database that is composed of Brazil's PMAQ external evaluation data, composed of 27 states.

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