The Lancet Regional Health - Americas xxx (xxxx) xxx

Contents lists available at ScienceDirect

The Lancet Regional Health - Americas

journal homepage: www.elsevier.com/locate/lana

Research paper

The quality of alternative models of primary health care and morbidity and mortality in Brazil: a national longitudinal analysis

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ARTICLE INFO

Article history:
Received 14 May 2021
Revised 23 July 2021
Accepted 23 July 2021
Available online xxx

ABSTRACT

Background: Evidence is limited on health benefits from quality improvement of primary healthcare (PHC) in low- and middle-income countries (LMICs). This study investigated whether increasing PHC quality in Brazil with highly-skilled health professionals and integrated community health workers (CHWs) was associated with reductions in hospitalizations and mortality beyond benefits derived from increasing access.

Methods: Annual municipal-level data for 5,411 municipalities between 2000 and 2014 were analysed using fixed effects panel regressions. PHC quality was measured as: i) the proportion of consultations provided by highly-skilled health professionals (doctors and nurses); and ii) the proportion of visits provided by CHWs from multidisciplinary PHC teams. Models assessed associations between PHC quality and hospitalization and mortality from diabetes, cardiovascular disease (CVD), tuberculosis, leprosy, perinatal and maternal causes, and adjusted for PHC access, utilisation, presence of secondary care services, and socioeconomic factors.

Findings: A one percentage point increase in the proportion of consultations provided by highly-skilled health professionals was associated with 0•019 fewer deaths from diabetes per 100,000 population (95%CI: -0•034, -0•003; p-value: 0.0167) and 0•029 fewer hospitalizations per 100,000 from leprosy (95%CI: -0•055, -0•002; p-value: 0.0321). A one percentage point increase in the proportion of care provided by CHWs from multidisciplinary PHC teams was associated with 0•025 fewer deaths from CVD per 100,000 (95%CI: -0•050, -0•001; p-value: 0.0442) and 0•148 fewer maternal hospital admissions per 100,000 (95%CI: -0•286, -0•010; p-value: 0.0356). No significant associations were found for the other twenty pairs of exposures and outcomes analysed.

Interpretation: Investing in higher-quality PHC models with highly-skilled health professionals and integrated CHWs can deliver reductions in mortality and hospitalizations in LMICs.

Funding: None.

Research in Context

Evidence before this study

PubMed and Google Scholar were searched for the terms “primary health care”, “model”, “program”, “quality”, “characteristics”, “comprehensiveness”, “access”, “coverage”, “mortality”, “morbidity”, and “hospitalizations”. Studies published since 2000 in English and Portuguese were included and complemented with studies known by the authors.

Evidence on primary healthcare (PHC) from low- and middle-income countries (LMICs) mostly focuses on access

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https://doi.org/10.1016/j.lana.2021.100034

to healthcare and demonstrates the health benefits from expanding access to PHC. In the Brazilian context, evidence links the expansion of PHC coverage with reductions in infant mortality, maternal mortality, NCD mortality, and health inequalities. However, robust evidence on the health benefits of different models of PHC and quality improvements is scant.

Evidence from Europe and the USA suggests stronger, higher quality PHC systems are associated with better health outcomes and slower growth in healthcare expenditure. In LMICs, the evidence on healthcare quality is sparse and does not rigorously evaluate the health impacts from improving quality or compare the performance of different models of PHC. Evidence on the performance of community health workers (CHW) as part of PHC teams is ambiguous and of low quality. No studies have robustly evaluated how introducing highly-skilled health professionals or better integrating CHWs into PHC services can affect health outcomes in LMICs.

Added value of this study

We applied robust econometric methods to detailed health service and mortality data from 5,411 Brazilian municipalities. We tested whether a higher-quality model of PHC was associated with improved health outcomes, after adjusting for healthcare access, utilisation, hospital care and socioeconomic factors. We measured PHC quality through the inclusion of highly-skilled health professionals and integration of CHWs into PHC teams. Higher quality PHC was associated with lower mortality from diabetes and cardiovascular diseases and fewer hospitalizations from maternal conditions and leprosy.

Implications of all the available evidence

High quality, multidisciplinary PHC remains essential to strengthening health systems in both high-income countries and LMICs. There may be tangible health benefits, beyond those derived from improving access, from increasing the quality of PHC in LMICs where highly-skilled health professionals and CHWs are included and integrated into PHC services.

1. Introduction

Progress towards the Sustainable Development Goals (SDGs), including Universal Health Coverage (UHC) (target 3.7), are major priorities for countries worldwide [1]. High-quality primary healthcare (PHC), which includes the delivery of accessible, comprehensive, coordinated, person-centred, and continuous primary care services, is key to meeting the SDGs and achieving UHC [2]. Global re-commitment to PHC with the Astana declaration in 2018 is testament to the essential role of PHC in health system strengthening [3]. Despite high-level commitment, investments in PHC are lacking particularly in low- and middle-income countries (LMICs).

Better evidence on the quality and impact of alternative models of PHC is important for driving policy change and strengthening health systems. Quality healthcare is safe, effective, people-centred, equitable, efficient, timely and integrated [4]. Evidence suggests stronger and higher quality PHC is associated with better CVD outcomes, fewer hospitalizations, and lower expenditures [5–7]. However, robust evaluations from LMICs are lacking [8].

Brazil has been a global exemplar for PHC strengthening with progressive investments in a national PHC system since the early 1990s [9]. This has included different models of PHC: the Program of Community Health Workers (*Programa de Agentes Comunitários de Saúde*; PACS) and the Family Health Program/Strategy (*Programa/Estratégia Saúde da Família*; PSF/ESF) (Panel 1) [9–12]. The PACS centred on community health workers (CHWs) tasked with monitoring, prevention and health promotion activities, whilst the PSF/ESF provides more comprehensive services through multidisciplinary family health teams (FHTs) including doctors and nurses working from a health clinic and the integration and oversight of CHW activities. In both programs, CHWs work delivering prevention and health promotion activities. Among other activities, they are expected to pay weekly visits to patients with specific conditions (e.g., pregnancy, diabetes, hypertension, tuberculosis, and leprosy) to overview adherence to treatment and serve as a link between them and other healthcare professionals. Evidence suggests that there is high variability in CHW performance and relationship with other members of PHC teams across municipalities [12]. Since 1998, federal financial incentives encouraged rapid growth of the PSF/ESF and the absorption of PACS into the PSF/ESF, providing a robust natural experiment.

Previous research on the PSF/ESF has almost exclusively focused on impacts from expanding access, whilst the quality of different models of PHC has been overlooked. Expansion of the PSF/ESF has been associated with reductions in infant mortality [13,14], maternal mortality [14], mortality from cardiovascular diseases (CVD) [15], mortality amenable to health care [16], and reductions in health inequalities [13,17]. Knowledge on the impact of PHC quality in Brazil is sparse or limited to sub-national studies and cross-sectional studies with limited causal inference [18–21]. Evidence using the Primary Care Assessment Tool (PCAT) has shown PSF/ESF services provide high quality care compared to other PHC services —i.e., they score higher in indicators related with relevant characteristics like comprehensiveness or longitudinality— [22,23], and that CHWs working under the PSF/ESF are better performing compared to other CHWs [24]. A recent study showed reductions in socioeconomic inequalities in the quality of PHC in Brazil in recent years [25]. However, robust evidence on the health benefits of different models of PHC and quality improvements is lacking.

This study addresses an important gap in the research literature by examining associations between implementation of an arguably higher quality model of PHC and hospitalizations and mortality in Brazilian municipalities between 2000 and 2014. Two measures are assessed as proxies for PHC quality: i) the proportion of consultations provided by highly-skilled health professionals (doctors and nurses); and ii) the proportion of CHW visits provided by CHWs working in multidisciplinary teams.

We argue that these metrics are important proxies of healthcare quality given the training and professional skillsets of doctors and nurses compared to CHWs, and evidence on the provision of higher-quality care from better supervision and integration of CHWs [26,27]. Additionally, these two metrics allow us to measure the change in PHC model from PACS to PSF/ESF, which in general provides higher-quality care than other PHC services in Brazil as documented with specific quality of care measurement tools [22,23]. More detailed data on quality of PHC is unfortunately neither available with high frequency nor for the PACS model of PHC.

Panel 1 – The PACS and PSF/ESF models of PHC in Brazil
The Program of Community Health Workers (*Programa de Agentes Comunitários de Saúde*; PACS) was created in 1991 aiming to reduce maternal and infant mortality in the poor Northern and North-East of the country. It quickly expanded nationwide in the late 1990's. It centred on community health workers (CHW) recruited from local communities and trained in identifying health conditions and delivering prevention and health promotion activities – predominantly through home visits. Teams of up to 30 CHWs were supervised by one nurse and monitored local registered populations. Services were initially focused on maternal care and child health, and later included specific conditions (including hypertension, diabetes, and tuberculosis) [9,11,12].

(*continued on next page*)

The Family Health Program (*Programa Saúde da Família*; PSF) was created in 1994 and is based on multidisciplinary Family Health Teams (FHT) composed of a minimum of a medical doctor, a nurse, a nurse auxiliary and between four and six CHWs. Each FHT is responsible for providing preventive and curative healthcare for approximately 1,000 local families. In 2006, The PSF was renamed the Family Health Strategy (*Estratégia Saúde da* Família; ESF) to reflect its role as the centre and key strategy of the public health system. Since 2008, the PSF/ESF also allowed FHTs to incorporate specialty doctors (e.g., psychiatrists, paediatricians, and gynaecologists) and other professionals (e.g., psychologists, social workers, and physiotherapists) to support primary care services. In FHTs, CHWs work under close supervision from nurses and receive continuous training from other health professionals [9,10,12].

2. Methods

2.1. Study design

This study was an observational longitudinal study during 2000-2014 with municipalities as the unit of analysis (n=5,411). Panel regression analyses were employed. These models are robust quasi-experimental methods used for policy evaluation that exploit variation in exposure and outcomes over time [16,28].

2.2. Data sources

Data were obtained from the Brazilian Ministry of Health, the Brazilian Institute of Geography and Statistics, and the Brazilian Ministry of Social Development (Table S1 in supplementary material). Municipal level PHC data included: the number of primary care consultations by primary care model (PACS or PSF/ESF) and by health professionals (doctors/nurses or home visits by CHWs) for five specific conditions (maternal care, diabetes, hypertension, tuberculosis, and leprosy); the number of Family Health Teams (FHT); and the number of CHWs. The number of hospitalizations and deaths by patients' municipalities of residence and ICD-10 codes for primary cause of admission/death were obtained. Annual municipal-level data on population estimates, the number of live births, the number of haemodialysis and chemotherapy treatments, the share of the population with private health insurance plans, municipal GDP per capita, and per capita expenditure with the *Programa Bolsa Família* (Brazil's main social assistance program) were also obtained. Finally, data from the 2000 and 2010 census were obtained on: municipal urbanization rate, municipal illiteracy rate (share of the population aged 15 or older that cannot read or write a simple note), the percentage of population in households with improved sewage treatment, and population with a per capita income less than half the minimum salary.

All data were obtained at or aggregated to annual municipal observations using a municipal grid that accounts for the creation of new municipalities over time. There were 5,411 municipal observations for 15 years (2000-2014) after 67 municipalities were omitted due to missing data. Excluded municipalities are all in São Paulo and Rio Grande do Sul states and are, on average, comparatively smaller, more urbanized, with better urban infrastructure, and richer than municipalities included in the analysis. They are municipalities that did not opt-in to federal programs of PHC in the years of our analysis (or did for only one year and therefore do not have variation in our variables of interest). Unfortunately, changes in Brazilian data systems mean data identifying which PHC programmes delivered services was not available after 2014.

2.3. Variables

Outcome measures were hospitalisations and mortality rates from diabetes, CVD, tuberculosis, leprosy, and perinatal and maternal causes. These conditions were identified as being of strategic importance by the Brazilian Ministry of Health since 2000, and therefore detailed data on PHC consultations for these conditions were collected [10]. For CVD, we selected ICD10 codes considered amenable to PHC by the Brazilian Ministry of Health [29]. Maternal deaths and hospitalizations related to labour and delivery were excluded. See Table S2 of the supplementary material for ICD10 codes. Mortality and hospitalization rates were expressed per 100,000 residents, except for maternal and perinatal conditions (per 1,000 live births).

The quality of PHC was captured through two variables of interest. The first was the proportion of primary care consultations provided by high-skilled health professionals (doctors and nurses) under the PSF/ESF model. This was generated for each of the five specific conditions with detailed PHC consultation data (maternal care, diabetes, hypertension, tuberculosis, and leprosy). The second was the proportion of CHW visits provided by CHWs from multidisciplinary PSF/ESF teams (i.e., better integrated and supervised CHWs). Both quality measures were generated for each municipality-year observation. Additional details on the construction of variables of interest are provided as supplementary material.

A range of covariates, for each municipality-year observation, were generated to adjust for potential confounding factors. To control for access to PHC, models were adjusted for: per capita PHC consultations with a doctor or nurse; per capita CHW visits (for the five conditions with detailed consultation data); and PHC coverage of the population (defined by the Brazilian Ministry of Health as one CHW per 575 residents and one FHT per 3450 residents — detailed definition of coverage variables can be found in the supplementary material). To adjust for the wider health system (beyond PHC), models included binary variables indicating the presence of haemodialysis and/or chemotherapy services in a municipality.

Time-varying municipal characteristics were also included as covariates to adjust for socioeconomic cofounders. These were: the percentage of the population aged 0 to 4, 5 to 9, 10 to 14, 15 to 19, 20 to 29, 30 to 39, 40 to 49, 50 to 59, and 60 or more years old; per capita municipal GDP; per capita expenditure on the *Programa Bolsa Familia - PBF* (Brazil's main social assistance program); and on the proportion of the population with private health insurance. Additionally, municipal-level census data from 2000 and 2010 were linearly interpolated and extrapolated to provide data on: urbanization rates; the percentage of the population living in households connected to sewage system; illiteracy rates; and the percentage of the population with per capita family income less than half minimum salary. All models also included 5,011 binary variables adjusting for municipality fixed effects and 405 binary variables adjusting for state-year (27 states x 15 years) fixed effects.

2.4. Statistical analysis

To assess the associations between PHC quality and population health outcomes, panel regression methods with fixed effects specification were employed. The models took the form of:

$$y_{mt} = \alpha + \beta_1 \times ShPSFconsultations_{MT} + \beta_2 \times ShCHWhomevisitsPSF_{mt} + \delta \times X_{mt} + \eta_m + \theta_{st} + \epsilon_{mt}$$

Where y_{mt} is the mortality rate or hospitalization rate (for different conditions) in municipality m in year t. $ShPSFconsultations_{mt}$ is the share of PHC services that are consultations with doctors or nurses enrolled in the PSF/ESF model. $ShCHWhomevisitsPSF_{mt}$ is the share of total CHW home visits that were delivered by CHWs enrolled in the PSF/ESF model. X_{mt} is a vector of time-varying covariates, which includes all control variables related

with healthcare and socioeconomic characteristics detailed above. The term η_m denotes dummy variables, one for each municipality (fixed effects), accounting for all time-invariant differences across municipalities, and θ_{st} are state-specific year fixed effects (non-parametric time-trends) accounting for all time-varying state-level non-observable factors. It is important to highlight that non-observed municipality-specific determinants of health outcomes and resource allocation might be correlated with our explanatory variables of interest and, therefore, the use of a random-effects model instead of a fixed-effects model would produce biased estimates.

The coefficients of interest are β_1 and β_2, which capture the association between the two PHC quality measures and population health outcomes (mortality or hospitalization rates) conditioned upon all the covariates, fixed effects and time trends noted above. Notably, the PHC quality measures capture associations related purely to the composition of PHC services as covariates in the models adjust for the magnitude and coverage of PHC services. Therefore, β_1 and β_2 should capture exclusively the association between changes in PHC quality and health outcomes. The models were repeated separately for hospitalisations and mortality for each of the six health outcomes (diabetes, CVD, tuberculosis, leprosy, and perinatal and maternal causes). Additionally, non-linear specifications of the PHC quality variables were tested in supplementary models. This was to examine for evidence of non-linear associations or marginal effects and done by including squared terms (of the PHC quality variables) in the models.

All regressions were weighted by the municipal population to account for heterogeneity across municipalities. Standard errors were clustered at the municipality level to account for serial correlation within municipalities.

2.5. Sensitivity analyses

Sensitivity analyses tested the robustness of our results. First, stepwise inclusion of covariates was undertaken to explore the stability of the estimates. Secondly, as the variables of interest (PHC quality measures) were computed as proportions, missing values were generated for municipal-year observations without data on PHC utilization. Those observations can have two different causes. It could be that some municipalities did not have any PHC team belonging to PSF/ESF or PACS program in some year (which would not necessarily mean that PHC utilization was zero, as other local arrangements of PHC could exist, but that data is not available); or it could be a data quality issue linked to PHC teams failing to report information to national health information systems. To test any effect on the findings, models were repeated using only a completely balanced panel of municipalities and omitting municipalities with missing information for any year. Third, models were repeated without weights for population size to assess any bias from weighting.

2.6. Role of the funding source

There was no funding source for this study. The corresponding author had access to all study data and responsibility for the decision to submit the paper for publication.

3. Results

Between 2000 and 2014, there was a large expansion of PHC coverage in Brazil under both the PSF/ESF and the PACS (Figure 1). The percentage of the population covered by CHWs (working in either PACS program or PSF/ESF program) increased from 38•9% in 2000 to 64•1% in 2014. The coverage of FHT (i.e., the PHC teams of the PSF/ESF program) increased from 13•9% in 2000 to 58•2% in 2014.

Over the period 2000-2014, the quality of PHC increased. Both the proportion of consultations provided by higher-skilled health professionals (doctors or nurses) and the proportion of CHW visits provided by CHWs from multidisciplinary PSF/ESF teams increased (Figure 2). In 2000, 52•1% of the PHC services for the five conditions analysed were delivered in the PSF/ESF program (33•3% as home visits by CHWs and 18•8% as consultations with a doctor or nurse). This increased to 92•8% in 2014 (62•9% as CHW visits and 29•8% as consultations) where only 7•2% of PHC care was provided under the PACS program (5•6% as CHW visits and 1•7% as nurse consultations). Therefore, the proportion of PSF/ESF consultations with higher-skilled health professionals increased 11 percentage points (PHC quality variable 1; from 18•8% to 29•8% of all services) between 2000 and 2014, and the proportion of CHW visits from CHWs in PSF/ESF grew 47•1 percentage points (PHC quality variable 2; from 44•8% to 91•9% of all CHW visits).

Table 1 shows summary statistics for all variables used in the analyses (weighted means are shown in Table S3 in the supplementary material). Between 2000 and 2014, the (unweighted) mean municipal mortality rate from diabetes was 24•4 per 100,000 residents, the CVD mortality rate was 82•8, the tuberculosis mortality rate was 1•7 and the leprosy mortality rate was 0.1. The hospitalisation rates were 86.6 per 100,000 for diabetes, 505•4 for CVD, 4•4 for tuberculosis and 2•5 for leprosy. The perinatal and maternal mortality rates were respectively 9•6 and 0•5 per 1000 live births and respective hospitalisation rates were 64•1 and 161•0 per 1000 live births.

Figure 3 shows the associations between PHC quality and hospitalizations for the six conditions from fully adjusted regression models. Detailed results are depicted in Table S4 in the supplementary material. A one percentage point increase in the proportion of PHC consultations delivered in the PSF/ESF was associated with 0•029 (95% CI: -0•055, -0•002) fewer hospitalizations per 100,000 residents from leprosy. This is a relative decrease of -1•1% and translates into a reduction of -12•5% in hospitalizations from leprosy given average changes over the period. The results also show that a one percentage point increase in the proportion of CHW visits from CHWs in PSF/ESF FHTs was associated with 0•148 (95% CI: -0•286, -0•010) fewer hospital admissions per 1000 live births from causes related to maternity. This translates into a -0•09% relative decrease and given average changes translates into a -4•3% decrease in the hospitalization rate from conditions related to maternity over the period. No significant association with hospitalizations from other causes was found, although the effect sizes for CVD indicates positive associations with PHC quality.

Figure 4 shows the association between the two measures of PHC quality and mortality for the six conditions from fully adjusted regression models (full regression results in Table S5 in the supplementary material). A one percentage point increase in the proportion of primary care consultations delivered in the PSF/ESF was associated with 0•019 (95% CI: -0•034, -0•003) fewer deaths from diabetes per 100,000. This corresponds to a relative decrease of -0•08% in the mean municipal mortality rate from diabetes over the period of analysis. Given an 11 percentage points increase in the proportion of consultations delivered in the PSF/ESF over the period of analysis, this translates into a -0•88% decrease in mortality from diabetes in the average municipality. Additionally, a one percentage point increase in the proportion of CHW visits from CHWs in PSF/ESF was associated with 0•025 (95% CI: -0•050, -0•001) fewer deaths from CVD per 100,000 residents – a relative decrease of -0•03%. Given a 47•1 percentage points increase in the proportion of CHW visits from CHWs in PSF/ESF FHTs over the period, this translates into a -1•4% decrease in mortality from CVD.

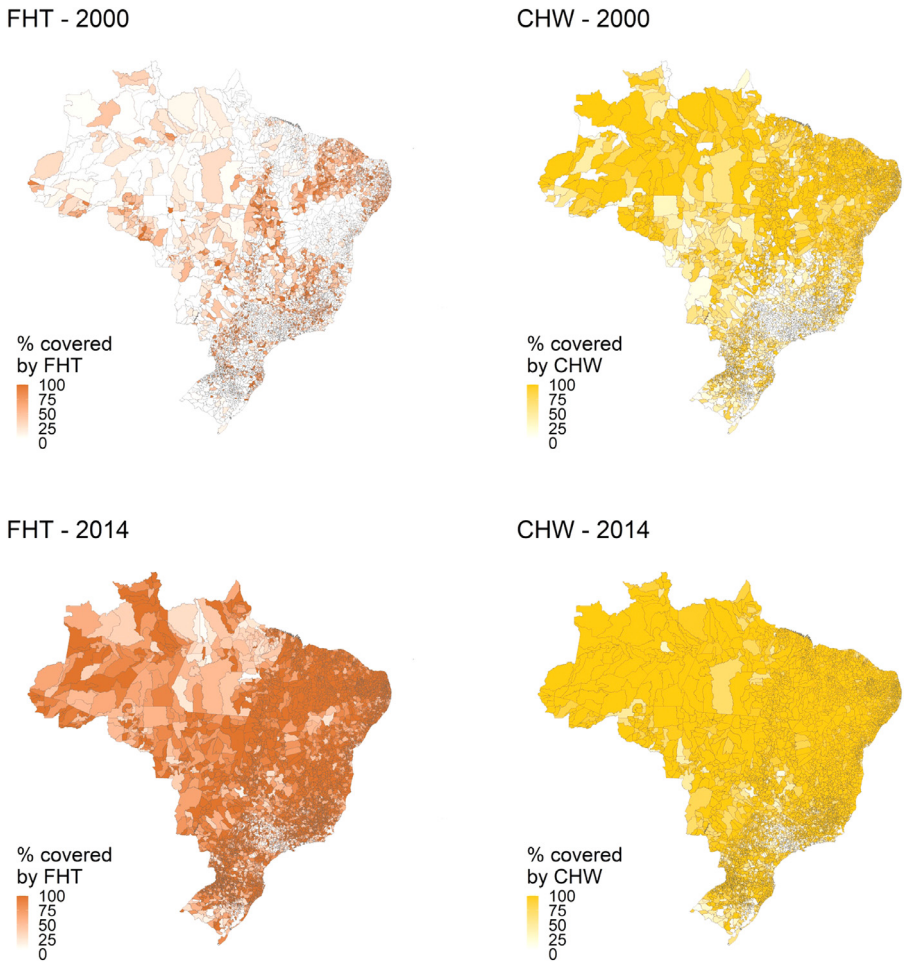

Figure 1. Family Health Teams (FHT) and Community Health Workers (CHW) coverage (2000 - 2014).
Note: the maps show the coverage of Family Health Teams - FHT (i.e., the PHC teams of the PSF/ESF program) and of Community Health Workers - CHW (who are present in both PACS and PSF/ESF programs) in Brazilian municipalities. Coverage was defined adopting the definition of the Brazilian Ministry of Health: (CHW*575)/population size and (FHT*3450)/population size (in both cases capped to 100%).

No significant association with mortality from other causes was found.

Non-linear relationships were tested by including squared PHC quality variables in the models (tables S6 and S7 in the supplementary material). Generally, the results show the coefficient for the non-linear term is opposite to the main (linear) coefficient, which implies decreasing marginal effect. Thus, as PHC quality increases, the associations with reductions in mortality and hospitalisations decrease in magnitude. Using these models, linear predictions were plotted for mortality rate from diabetes and hospitalization rates from leprosy (Figure S1 in the supplementary material) for different values of the share of PSF/ESF consultations. Wide confidence intervals limit clear interpretation of optimal levels of PHC quality variables.

The results were robust to sensitivity analysis (Tables S8-S11 and Figures S2-S3 in the supplementary material). Most coefficients remained stable to different specifications, suggesting the results were not driven by specification choice and modelling of age structure. In general, coefficients from unweighted regressions showed less stability, which is expected given that they are more sensitive to the presence of outliers. However, the only coefficient that failed to reach significance at any of the conventional levels was the coefficient showing the association between the share of PSF/ESF consultations and hospitalizations from leprosy from the unweighted regression.

4. Discussion

This study found that increasing PHC quality was associated with reductions in hospitalizations from maternal conditions and leprosy and reductions in mortality from diabetes and CVD. These findings suggest that increasing quality with the expansion of highly-skilled health professionals and better integration and supervision of CHWs in PHC teams can drive health gains beyond those realised from improving access and utilisation.

The association between increasing quality and reductions in mortality and hospitalisations are a plausible and expected finding. Global evidence demonstrates the link between low-quality care and higher mortality [30]. Studies from high-income countries link PHC quality with better health outcomes including reductions in mortality and hospitalisations [5–7]. In LMICs, few studies have robustly examined quality improvement and health outcomes. In Brazil, evidence focuses on access to PHC showing expansion of the PSF/ESF is associated with lower mortality [13–18], whilst studies on quality remain scarce [18–21].

Increasing PHC quality, by introducing higher-skilled health professionals and increasing the supervision of CHWs, likely increases the range of clinical services available to patients, improves the quality and effectiveness of these services, and strengthens activities for health prevention, promotion, and education. Appropriate supervision of CHW is essential for maximizing their effec-

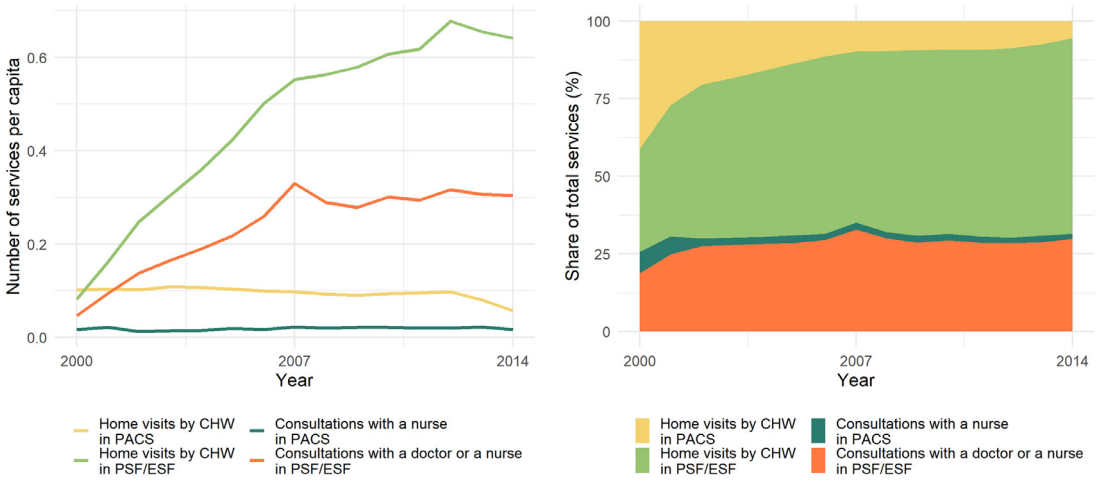

Figure 2. PHC services per capita for specific conditions by kind of service and professional (2000 - 2014).
Note: the figure shows services delivered in PHC units for the five conditions for which we have detailed information according to the kind of service and professional who delivered it and the model of PHC provision.

Table 1
Summary statistics.

	Mean	SD
Exposure variables		
Share of PSF/ESF consultations (%)	25.79	14.53
Share of CHW visits in PSF/ESF model (%)	83.16	30.45
Death rates (per 100,000 residents)		
Diabetes	24.40	22.84
Cardiovascular diseases	82.78	50.80
Maternal (per 1,000 births)	0.500	2.245
Perinatal (per 1,000 births)	9.615	11.38
Tuberculosis	1.691	4.585
Leprosy	0.139	1.367
Hospitalization rates (per 100,000 residents)		
Diabetes	86.59	86.59
Cardiovascular diseases	505.4	381.6
Maternal (per 1,000 births)	161.0	142.3
Perinatal (per 1,000 births)	64.14	89.24
Tuberculosis	4.442	14.33
Leprosy	2.531	75.98
Covariates		
PHC access and coverage		
CHW coverage (%)	84.01	28.91
FHT coverage (%)	69.31	36.29
N. of CHW home visits per capita	0.954	0.671
N. of consultations per capita	0.409	0.485
Age groups (%)		
0 to 4 years old	8.637	2.227
5 to 9 years old	9.291	2.024
10 to 14 years old	9.692	1.664
15 to 19 years old	9.689	1.313
20 to 29 years old	16.78	1.652
30 to 39 years old	14.05	1.648
40 to 49 years old	11.91	2.144
50 to 59 years old	8.865	2.143
60 or more years old	11.08	3.221
Additional covariates		
GDP per capita (in R$ 1,000)	11.50	13.38
PBF expenditure per capita (in R$)	79.14	93.79
Population with private health insurance (%)	6.340	11.55
Presence of haemodialysis and/or chemotherapy services	0.0451	0.207
Urbanization rate (%)	62.30	22.39
Population with family per capita income < 1/2 minimum salary (%)	50.89	22.92
Illiteracy rate (%)	12.24	7.001
Population with improved sewage (%)	26.68	30.36

Note: The table shows summary statistics for the 5,411 municipalities used in the analysis. Reported means are not weighted by population size. Share of PSF/ESF consultations: consultations with a medical doctor or nurse working in the PSF/ESF model as share of the total production of PHC services for five specific conditions (pregnancy, diabetes, hypertension, tuberculosis, and leprosy). Share of CHW visits in PSF/ESF model: share of all Community Health Workers visits to patients of any of the five specific conditions done by CHW working in the PSF/ESF model.

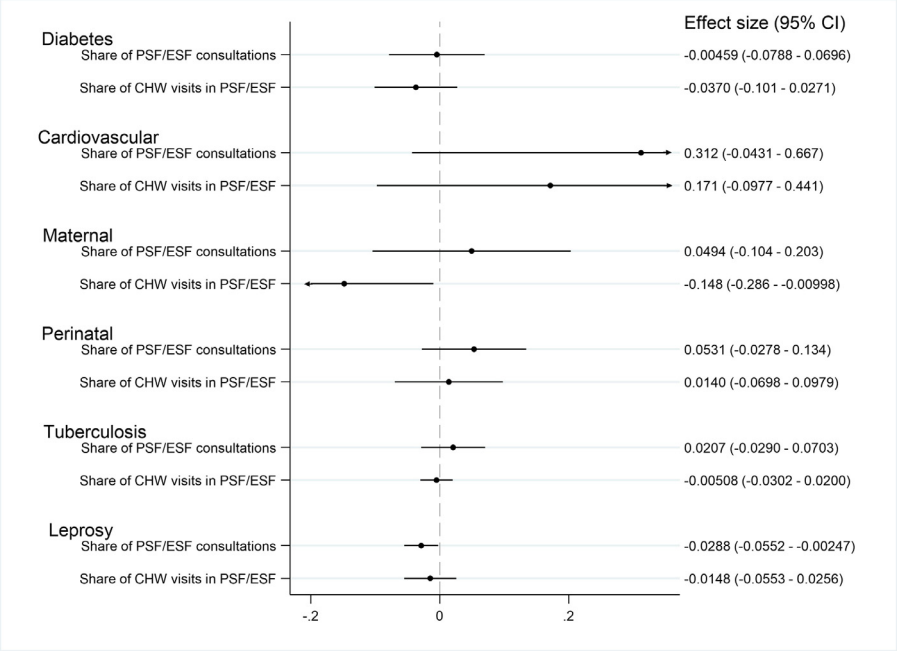

Figure 3. Association between primary healthcare quality and hospitalizations from different conditions.
Note: All regressions included as covariates FHT coverage, CHW coverage, N. of consultations for specific conditions per capita, N. of CHW visits for specific conditions per capita, per capita GDP, per capita expenditure with PBF, share of the population with private health insurance, binary variable indicating presence of chemotherapy and/or haemodialysis services, urbanization rate, share of the population with family per capita income < 1/2 minimum salary, illiteracy rate, share of the population with improved sewage, age structure, municipality fixed effects and state-specific year fixed effects. Regressions weighted by population size. Standard errors clustered at the municipality level.

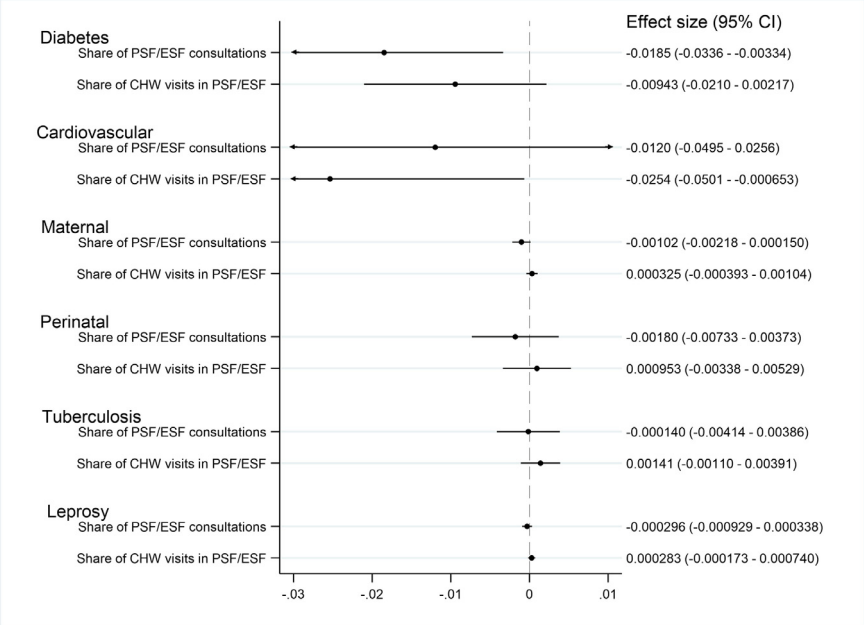

Figure 4. Association between primary healthcare quality and mortality from different conditions.
Note: All regressions included as covariates: FHT coverage, CHW coverage, N. of consultations for specific conditions per capita, N. of CHW visits for specific conditions per capita, per capita GDP, per capita expenditure with PBF, share of the population with private health insurance, binary variable indicating presence of chemotherapy and/or haemodialysis services, urbanization rate, share of the population with family per capita income < 1/2 minimum salary, illiteracy rate, share of the population with improved sewage, age structure, municipality fixed effects and state-specific year fixed effects. Regressions weighted by population size. Standard errors clustered at the municipality level.

tiveness and quality of care [26,27]. Preventing the development and exacerbation of CVD and diabetes required the continual management of multiple risk factors – something higher quality PHC is better suited to. These interventions are effective in managing chronic diseases, including diabetes and CVD, and can be delivered effectively through PHC in LMICs [31]. Since 2001, the Brazilian Ministry of Health has set diabetes and hypertension control as strategic goals, and mandated the provision of services central to high-quality PHC: health prevention and health promotion, active searching, diagnosing, treating and monitoring of patients,

early prevention of complications, and referral to secondary care [10]. Beyond CVD risk factors, reductions in admissions for maternal conditions and leprosy likely relate to more and better-quality prenatal care, and earlier diagnosis and access to infectious disease treatments. Although the effect estimates were non-significant, there was a positive association between CVD hospitalisations and PHC quality that suggests the associated reductions in CVD mortality could be partly driven through increased referral to secondary care.

However, identified effect sizes were relatively small and there could be concerns about the efficiency of increasing PHC quality. Monthly transfers from the federal government were almost twice the size per PSF/ESF team than per PACS team (see Appendix 4 in the supplementary material for details). Given that studies show that human resources account for a large proportion of PSF/ESF costs and that physicians' salaries —on average— are over twofold those of nurses and around eight times those of CHWs [32], further studies about the cost-effectiveness of increasing PHC quality through the inclusion of highly trained professionals are needed. Still, it would be important to assess any impacts beyond those related to hospitalization and mortality rates as well since access to quality care can be related to non-observable improvements in health conditions and quality of life in general.

The two measures of PHC quality may be capturing higher quality of inputs (such as more trained staff) and different organizational arrangements rather than reflecting the actual quality of care delivered. This is more salient for the case of the proportion of consultations provided by more trained providers. In other settings, provider training has been shown to be less relevant for the quality of healthcare services than provider effort [33,34]. However, it is relevant to highlight that our research design allows us to control, at least to some extent, for different levels of provider efforts, as we include the volume of services delivered as a covariate. As catchment areas for PHC teams are roughly the same size across the country and fixed-effects are expected to absorb differences in the epidemiological conditions of municipalities, variations in the volume of services delivered are expected to be related to provider effort and not only to case load —granted, the effort exerted by providers in each consultation remains unobservable in our design. Considering all these factors, we hypothesize that our two variables of interest are likely associated with higher quality of PHC.

Our study has limitations. First, it is possible that administrative data on mortality suffer from underreporting or bad reporting of ICD10 codes in some areas and there could be potential biases. However, differences in reporting patterns across municipalities are captured with municipality fixed effects reducing biases from time invariant factors. Changes in underreporting are unlikely to be sharply associated with changes in PHC quality. Secondly, the analysis is ecological and precludes causal inference at the individual level. However, models accounted for all unobserved time invariant differences across municipalities and time variant differences across states, and multiple observed confounders were also adjusted for. Sensitivity analysis were also conducted to test the robustness of the results. Thirdly, measures related to PHC quality were limited by the available data. While there are arguments supporting the view that the measures used are good proxies of PHC quality, as previously discussed, analysis using more robust indicators related directly to clinical care should be developed. Unfortunately, that kind of indicators are neither available with high frequency nor for the PACS model of PHC. Further studies leveraging different data sources and methodological strategies could help to further disentangle how quality of PHC relates to health outcomes. Despite these limitations, this study is one of the first to robustly examine the health impacts of PHC quality in a LMIC and employ models to adjust for access and volume of services delivered.

Overall, the results from this study indicate that additional health benefits can be gained from moving beyond a focus on increased healthcare access to ensuring that care provided is of high quality. High quality PHC is essential in managing chronic diseases and ensuring sustainability of health systems. Our findings underline the important roles of highly-skilled health professionals and integrated and appropriately-supervised CHWs in achieving this. Recent financing reforms in Brazil which reduce the mandatory number of CHWs in primary care teams from four to one threaten the quality of services and could erode health gains in the last decades [35].

5. Conclusion

Improving the quality of PHC in Brazil in recent decades has been associated with reductions in hospitalisations and mortality. These findings contribute to growing evidence on the importance of high-quality PHC in LMICs for improving population health and making progress towards health-related SDGs.

Contributors

MM and RR jointly conceived the study and developed the study outline with TH and CM. MM compiled the data, and MM and RR did the analysis. MM and RR wrote the first draft with input from TH and CM. All authors contributed to the subsequent drafts and to the final manuscript equally. MM and RR accessed and verified the underlying data. All authors had final responsibility for the decision to submit for publication.

Declaration of Interest

The author declare they all have no conflicts of interest.

Data Sharing

All data used in this study are publicly available from the sources listed in table S1 in the supplementary material.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lana.2021.100034.

Editor's note

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References

[1] United Nations Department for Economic and Social Affairs Sustainable Development Goals Report 2020. New York: United Nations Publications; 2020.
[2] Hone T, Macinko J, Millett C. Revisiting Alma-Ata: what is the role of primary health care in achieving the Sustainable Development Goals? The Lancet 2018;392(10156):1461–72 Oct.
[3] Global Conference on Primary Health Care. Declaration of Astana. Astana; 2018 Oct.
[4] World Health Organization Quality in Primary Health Care; 2018. (Technical series on Primary Health Care).
[5] Kringos DS, Boerma W, van der Zee J, Groenewegen P. Europe's Strong Primary Care Systems Are Linked To Better Population Health But Also To Higher Health Spending. Health Affairs 2013;32(4):686–94 Apr.
[6] Levene LS, Bankart J, Khunti K, Baker RGorlova OY, editor. Association of Primary Care Characteristics with Variations in Mortality Rates in England: An Observational Study. editor. PLoS ONE 2012;7(10):e47800 Oct 24.
[7] Baker R, Freeman GK, Haggerty JL, Bankart MJ, Nockels KH. Primary medical care continuity and patient mortality: a systematic review. Br J Gen Pract 2020;70(698):e600–11 Sep.
[8] Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-DeWan S, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. The Lancet Global Health 2018;6(11):e1196–252 Nov.

[9] Castro MC, Massuda A, Almeida G, Menezes-Filho NA, Andrade MV, de Souza Noronha KVM, et al. Brazil's unified health system: the first 30 years and prospects for the future. The Lancet 2019;394(10195):345–56 Jul.
[10] DAB/Ministério da SaúdePrograma Saúde da Família: ampliando a cobertura para consolidar a mudança do modelo de Atenção Básica. Rev Bras Saude Mater Infant 2003;3(1):113–25 Mar.
[11] Brasil. Ministério da Saúde Programa Agentes Comunitários de Saúde (PACS). Brasília: Ministério da Saúde; 2001.
[12] Lotta G. Burocracia e implementação de políticas de saúde: os agentes comunitários na Estratégia Saúde de Família. Rio de Janeiro: Scielo Editora Fiocruz; 2015.
[13] Rocha R, Soares RR. Evaluating the impact of community-based health interventions: evidence from Brazil's Family Health Program. Health Econ 2010;19(S1):126–58 Sep.
[14] Bhalotra S, Rocha R, Soares, RR. Does Universalization of Health Work? Evidence from Health Systems Restructuring and Maternal and Child Health in Brazil. IEPS Working Paper Series. 3rd ed. 2020.
[15] Rasella D, Harhay MO, Pamponet ML, Aquino R, Barreto ML. Impact of primary health care on mortality from heart and cerebrovascular diseases in Brazil: a nationwide analysis of longitudinal data. BMJ 2014;349(jul03 5):g4014 Jul 3 –g4014.
[16] Hone T, Rasella D, Barreto M, Atun R, Majeed A, Millett C. Large Reductions In Amenable Mortality Associated With Brazil's Primary Care Expansion And Strong Health Governance. Health Affairs 2017;36(1):149–58 Jan.
[17] Hone T, Rasella D, Barreto ML, Majeed A, Millett C. Association between expansion of primary healthcare and racial inequalities in mortality amenable to primary care in Brazil: A national longitudinal analysis. Tsai AC, editor. PLoS Med. 2017;14(5):e1002306 May 30.
[18] Bastos ML, Menzies D, Hone T, Dehghani K, Trajman A. The impact of the Brazilian family health on selected primary care sensitive conditions: A systematic review. Zeeb H, editor. PLoS ONE 2017;12(8):e0182336 Aug 7.
[19] Castro DM de, Oliveira VB de, Andrade AC de S, Cherchiglia ML, Santos A de F dos. Impacto da qualidade da atenção primária à saúde na redução das internações por condições sensíveis. Cad Saúde Pública 2020;36(11): e00209819.
[20] Schilling Mendonça C, Bielefeldt Leotti V, Soares Dias-da-Costa J, Harzheim E. Hospitalizations for primary care sensitive conditions: association with socioeconomic status and quality of family health teams in Belo Horizonte, Brazil. Health Policy and Plan 2017;32(10):1368–74 Dec 1.
[21] Guerra AB, Guerra LM, Probst LF, Gondinho BVC, Ambrosano GMB, Melo EA, et al. Can the primary health care model affect the determinants of neonatal, post-neonatal and maternal mortality? A study from Brazil. BMC Health Serv Res 2019;19(1):133 Dec.
[22] Silva CS de O e, Fonseca ADG, Souza LPS e, Siqueira L das G, Belasco AGS, Barbosa DA. Integralidade e Atenção Primária à Saúde: avaliação sob a ótica dos usuários. Ciênc saúde coletiva 2014;19(11):4407–15 Nov.
[23] Macinko J, Almeida C, Oliveira E dos S, Klingelhoefer de Sá P. Organization and delivery of primary health care services in Petrópolis, Brazil: Primary Health Care in Petropolis. Int J Health Plann Mgmt 2004;19(4):303–17 Oct.
[24] Ibañez N, Rocha JSY, Castro PC, de Ribeiro, MCS de A, Forster AC, Novaes MHD, et al. Avaliação do desempenho da atenção básica no Estado de São Paulo. Ciênc saúde coletiva 2006;11(3):683–703 Sep.
[25] Kovacs R, Maia Barreto JO, da Silva EN, Borghi J, Kristensen SR, Costa DRT, et al. Socioeconomic inequalities in the quality of primary care under Brazil's national pay-for-performance programme: a longitudinal study of family health teams. The Lancet Global Health 2021;9(3):e331–9 Mar.
[26] Scott K, Beckham SW, Gross M, Pariyo G, Rao KD, Cometto G, et al. What do we know about community-based health worker programs? A systematic review of existing reviews on community health workers. Hum Resour Health 2018;16(1):39 Dec.
[27] Kok MC, Dieleman M, Taegtmeyer M, Broerse JE, Kane SS, Ormel H, et al. Which intervention design factors influence performance of community health workers in low- and middle-income countries? A systematic review. Health Policy Plan 2015;30(9):1207–27 Nov.
[28] Hone T, Mirelman AJ, Rasella D, Paes-Sousa R, Barreto ML, Rocha R, et al. Effect of economic recession and impact of health and social protection expenditures on adult mortality: a longitudinal analysis of 5565 Brazilian municipalities. The Lancet Global Health 2019;7(11):e1575–83 Nov.
[29] Alfradique ME, Bonolo P de F, Dourado I, Lima-Costa MF, Macinko J, Mendonça CS, et al. Internações por condições sensíveis à atenção primária: a construção da lista brasileira como ferramenta para medir o desempenho do sistema de saúde (Projeto ICSAP - Brasil). Cad Saúde Pública 2009;25(6):1337–49 Jun.
[30] Kruk ME, Gage AD, Joseph NT, Danaei G, García-Saisó S, Salomon JA. Mortality due to low-quality health systems in the universal health coverage era: a systematic analysis of amenable deaths in 137 countries. The Lancet 2018;392(10160):2203–12 Nov.
[31] Beaglehole R, Epping-Jordan J, Patel V, Chopra M, Ebrahim S, Kidd M, et al. Improving the prevention and management of chronic disease in low-income and middle-income countries: a priority for primary health care. The Lancet 2008;372(9642):940–9 Sep.
[32] Vieira R da S, Servo LMS. Estimativas de custos dos recursos humanos em atenção básica: Equipes de Saúde da (ESF) e Equipes de Saúde Bucal (ESB), Brasília: IPEA; 2013. (Nota Técnica N. 16).
[33] Das J, Hammer J. Quality of Primary Care in Low-Income Countries: Facts and Economics. Annu Rev Econ 2014;6(1):525–53 Aug.
[34] Das J, Holla A, Mohpal A, Muralidharan K. Quality and Accountability in Health Care Delivery: Audit-Study Evidence from Primary Care in India. American Economic Review 2016;106(12):3765–99 Dec 1.
[35] Massuda A. Mudanças no financiamento da Atenção Primária à Saúde no Sistema de Saúde Brasileiro: avanço ou retrocesso? Ciênc saúde coletiva 2020;25(4):1181–8 Apr.