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Original Research

Macrodetermined racial inequalities in diagnostic testing among tuberculosis patients in Brazil

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ABSTRACT

Objectives: To estimate the association between tuberculosis (TB) patients' race and patients' access to diagnostic testing in Brazil. In addition, we evaluated if the associations could be explained by a geographic codistribution between racial groups and diagnostic testing.

Study design: It is a cross-sectional study based on secondary data from a national surveillance system of new TB cases diagnosed in 2015.

Methods: We evaluated the association between TB patients' race (independent variable) and the HIV testing and TB mycobacterial culture providing (dependent variables) with logistic regression models. We used multilevel models to consider different geopolitical levels (region, state and municipality). In addition, we used conditional logistic regressions matched by health-care unit. All models were adjusted by individual covariates associated with the outcomes.

Results: Compared with non–Afro-Brazilian patients, Afro-Brazilian patients had significantly lower odds to have had HIV testing [odds ratio (OR): 0.72; 95% confidence interval (CI): 0.69–0.75] and mycobacterial culture performed (OR: 0.74; 95% CI: 0.71–0.77). However, these statistically significant negative associations between Afro-Brazilian racial category and testing disappeared when patients were considered as nested in geopolitical contexts or matched for health-care unit.

Conclusions: Afro-Brazilian TB patients had lower probability to have HIV test and mycobacterial culture performed. However, these associations seem to be macrodeterminated by the geographic distribution of both racial groups and diagnostic testing. Our findings can support the formulation of public policies aiming to mitigate regional disparities as a strategy to improve racial equity in access to healthcare. The approach presented can be applied in a range of scenarios to identify disparities, localize its source and support decision-making.

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Introduction

Brazil is a middle-income country in South America with continental dimension and a high burden of tuberculosis (TB).[1] The country has had an important reduction in household income inequality in the last 20 years; however, it still is one of the world's most unequal countries,[2] and since 2015 public health expenditure per capita has declined because of economic and political crises, combined with austerity policies.[3]

Historically, Brazil has exhibited racial inequalities that reflect social disparities.[4] Although Afro-Brazilians are 53.9% of the Brazilian population, they were 73.5% more exposed to poor living conditions than the white population.[5] Moreover, Afro-Brazilians have less access to health-care provision than the white people.[4] Therefore, they are more likely to be exposed to precarious living conditions, increasing the risk of communicable diseases such as TB.[6–9] In addition, the quality indicators of TB patients' care are worse for the black and mixed race people than for the white people.[9]

Mycobacterial culture is a sensitive diagnostic test for TB,[10] and in Brazil, it is recommended for all persons with presumptive TB evaluated by smear microscopy or those diagnosed by automated molecular tests.[11] In addition, HIV testing is also recommended for all TB patients[11] because it enables early starting of antiretroviral therapy, which reduces mortality rates.[12] Although those diagnostic tests are provided for free, it has been described that black and mixed race TB patients had lower frequency of these tests performed than white TB patients.[9]

Identifying the factors that influence testing, particularly regarding racial disparities, may develop evidence bases to improve strategies to mitigate health inequalities. In such context, this study aimed to evaluate the association between TB patients' race and their access to HIV testing and mycobacterial culture in Brazil. Furthermore, we evaluated if the associations could be explained by the geographic codistribution of racial groups and diagnostic testing.

Methods

This is a cross-sectional study based on secondary data from a national surveillance system. We analysed the new TB cases diagnosed in 2015 that were notified in the Brazilian National Information System for Notifiable Diseases (Sinan). In Brazil, all TB cases are compulsorily notified by health services in Sinan and the characteristics of the patients and disease, the follow-up and outcome are also registered in this information system. These data are available by request at the Brazilian Ministry of Health.

We evaluated the association between TB patients' race and the dependent variables (HIV testing and mycobacterial culture) using logistic regression models. We used multilevel regression models to nest patients in different geopolitical levels (region, state and municipality) to examine the associations between the dependent variables and race. Besides that, we used conditional logistic regression to adjust for the institutional level (health-care unit).

The race classification used in Brazil's national census includes the following categories: black, brown or mixed race, white, Asian and indigenous. In this study, race was the main independent variable, and it was recategorised into Afro-Brazilian (black and brown/mixed race) and non–Afro-Brazilian (white, Asian and indigenous). Classifying black and brown/mixed race people as a single collective—Afro-Brazilian (*negro,* in Portuguese)—is an accepted practice among researchers and is also an official categorization established by the Brazilian Law nº 12.288, of 20 July 2010.[13,14]

All models were adjusted by the covariates that were associated with the dependent variable ($P < 0.05$) or that modified (>10%) the association with race. The covariates were selected by a manual stepwise forward method. As covariates, we analysed the individual variables available in the database with completeness of at least 80%. These variables were sex (women and men), age (0–14, 15–39, 40–59 and 60 years and older), clinical manifestation (pulmonary and extrapulmonary/mixed form), TB-HIV co-infection, alcohol use disorder, diabetes, mental disorder, prisoner and transference (TB cases that were followed by a different unit from the one that notified them).

First, univariable logistic regressions were used to explore the unadjusted associations of each covariate to the dependent variables; multiple logistic regressions were used to explore the adjusted associations later on. Then, in three separated multilevel regression models, we evaluated the association between TB patients' race and the dependent variables considering the geopolitical levels (region, state and municipality). In addition, we performed secondary multilevel analyses for each Brazilian region where patients were nested in municipalities. Considering that there are five regions and we evaluated two dependent variables (obtaining ten secondary models), we established the significance level at 0.005.[15]

Hereupon, we used a conditional logistic regression to make an adjustment for the health-care unit level. We chose the last method because there were multiple health-care units and many of them had only one case, which would not lead to a functional clustering to control by context. For this approach, observations of the units with only positive or negative outcomes were excluded. Consequently, we excluded 18,421 observations (8435 health-care units) for the HIV test model and 16,435 observations (8481 healthcare units) for the mycobacterial culture model. In this way, using conditional regression, we analysed each institution as a stratum (or matched set). This is an efficient strategy to adjust for a variable with a large number of categories relative to the number of observations.[16] The regression coefficients of the variable race obtained in these models were presented graphically.

We also performed two sensitive analyses. First, we obtained a model that includes only black (excluding the brown/mixed race) category, which was compared with the category of only white TB patients (supplemental file 1). Second, considering that Afro-Brazilians are over represented in prisons in Brazil,[17] we also ran the models limited to the non-institutionalized population (supplemental file 2).

All analyses were performed using Stata/MP 12.0 for Windows (64-bit ×86-64) from StataCorp LP. We used the QGIS

(geographic information system) software, Open Source Geospatial Foundation 2.18.15, to produce the maps. This study does not include identifiable information from TB patients, and data is publicly available in Brazil. As such, it was not necessary to submit the study to an institutional review board, which is in accordance with Resolution Nº 510 of the National Health Council of Brazil.[18]

Results

There were 67,791 new TB cases diagnosed in 2015 in Brazil, which were treated in 13,319 different health-care units. Regarding race, 57.6% of TB cases were Afro-Brazilians, 34.5% were non–Afro-Brazilians, and in 8% of the cases, race was not recorded. HIV testing and mycobacterial culture were performed in 73.8% and 25.2% of TB patients, respectively. The percentage of TB patients who had diagnostic testing performed varied geographically. Overall, states with a higher percentage of Afro-Brazilian TB patients also had a higher percentage of TB cases without diagnostic testing performed (Fig. 1).

HIV testing was performed on 72% of Afro-Brazilian patients and 78.1% of non–Afro-Brazilian patients. With regard to mycobacterial culture, 23.2% of Afro-Brazilian patients and 29% of non-Afro-Brazilian patients had the test performed (Table 1). In the models where patients were not nested in geopolitical contexts, Afro-Brazilian patients exhibited a statistically significant lower odds of HIV testing (odds ratio [OR]: 0.73; 95% confidence interval [CI]: 0.7–0.76; $P < 0.001$) and mycobacterial culture (OR: 0.75; 95% CI: 0.72–0.78; $P < 0.001$) than non–Afro-Brazilian patients (Table 1).

However, these negative associations lost statistical significance in the multilevel models where patients were nested in geopolitical context and in the logistic regressions matched for health-care unit (Fig. 2). In fact, in the multilevel analyses in which patients were nested in municipalities for each Brazilian region (Fig. 3), we did not find any significant association between race and HIV testing or mycobacterial culture.

Regarding individual covariates, in the multiple conditional model, the following categories were statistically associated with a higher HIV testing: age of 15 years and older (15–39, 40–49 or 60 years and older); extrapulmonary/mixed form; alcohol use disorder; and mycobacterial culture. Moreover, prisoners were statistically associated with a lower HIV testing (Table 2). Furthermore, the following categories were statistically associated with a higher mycobacterial culture performance: men, 15 years and older; HIV testing and prisoners. Extrapulmonary/mixed form and transference were statistically associated with a lower mycobacterial culture performance (Table 2).

In the sensitivity analyses, we observed a consistent negative association of the performance of the tests with the black and Afro-Brazilian racial categories in non-nested models. However, these negative associations were

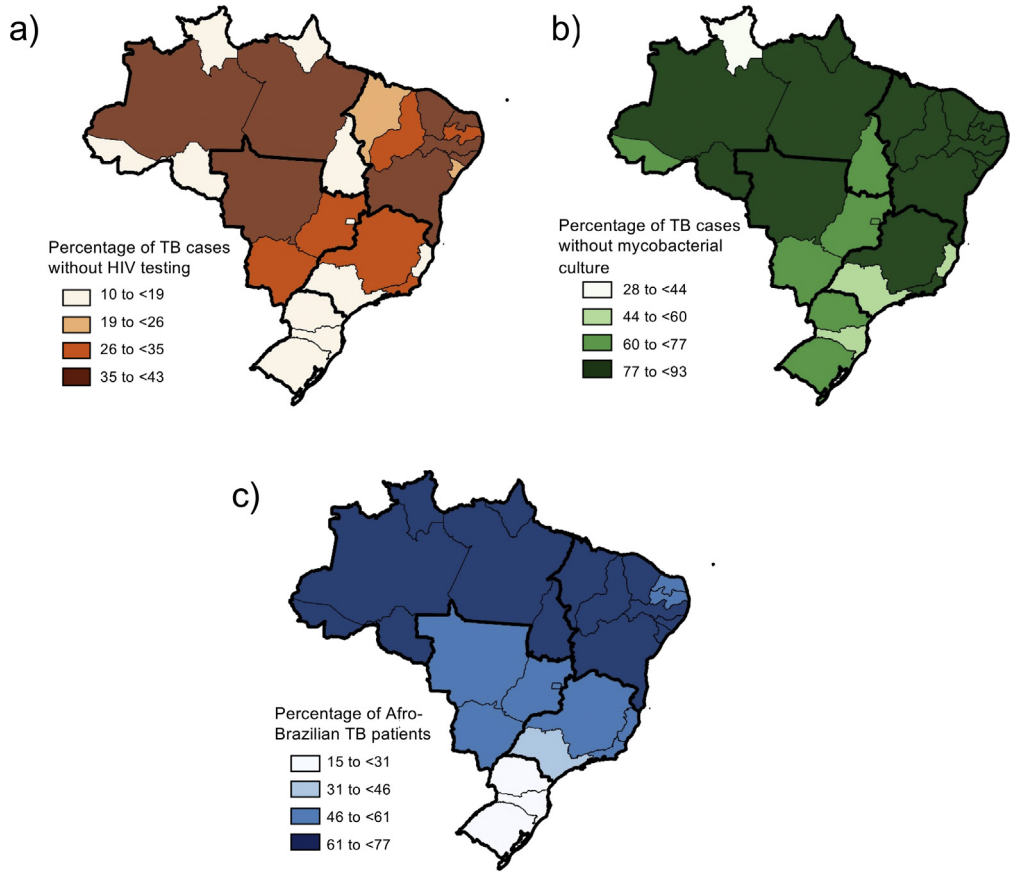

Fig. 1 – Percentage of tuberculosis (TB) cases without HIV testing (A) and without mycobacterial culture (B) and percentage of Afro-Brazilian population among TB patients (C) per region (bold line) and state (light line), Brazil, 2015.

Table 1 – Frequency of tuberculosis patients and association of HIV testing and mycobacterial culture by independent variables (n = 67.791), Brazil, 2015.

Variable	n	HIV testing		Mycobacterial culture	
		%	Adjusted OR (95% CI)	%	Adjusted OR (95% CI)
Race					
Non–Afro-Brazilian	23,370	78.1	1	29	1
Afro-Brazilian	39,025	72	0.73 (0.7–0.76)	23.2	0.75 (0.72–0.78)
Unknown	5396	67.4	–	23.8	–
Sex					
Women	21,709	72.5		22.4	1
Men	46,078	74.3		26.6	1.13 (1.08–1.18)
Unknown	4	100		0	–
Age in years					
0–14	2125	61.1	1	14.4	1
15–39	34,278	76.7	2.23 (2.01–2.49)	27.2	1.7 (1.48–1.95)
40–59	21,333	74.6	2 (1.8–2.23)	24.5	1.66 (1.44–1.9)
60+	10,024	64.8	1.26 (1.12–1.41)	22.3	1.58 (1.37–1.83)
Unknown	31	64.5	–	25.8	–
Clinical manifestation					
Pulmonary	56,791	72.9	1	26.6	1
Extrapulmonary/mixed form	10,958	78.5	1.4 (1.32–1.49)	18.1	0.57 (0.54–0.61)
Unknown	42	4.8	–	0	–
HIV coinfection					
Yes	6643	–	–	27.1	
No	43,363	–	–	29.3	
Unknown	17,785	–	–	14.6	
Alcohol use disorder					
Yes	10,526	77.2	1.24 (1.17–1.32)	27	
No	52,050	75	1	25.9	
Unknown	5215	54.6	–	14.6	
Diabetes					
Yes	4913	70.3	0.87 (0.81–0.94)	24.8	
No	57,329	76	1	26.3	
Unknown	5549	54.2	–	14.8	
Mental disorder					
Yes	1442	72.3		23.4	
No	60,620	75.6		26.4	
Unknown	5729	54.2		13.5	
Prisoner					
Yes	5652	74.5	0.73 (0.68–0.79)	44	2.24 (2.1–2.39)
No	54,531	75.5	1	25.1	1
Unknown	7608	61.1	–	12.1	–
Transference					
Yes	12,030	78.4	1.27 (1.2–1.34)	29.5	1.22 (1.16–1.28)
No	55,452	72.8	1	24.3	1
Unknown	309	64.4	–	21.4	–
HIV testing					
Yes	50,006	–	–	29	2.4 (2.27–2.52)
No	17,785	–	–	14.6	1
Mycobacterial culture					
Yes	17,115	84.9	2.39 (2.27–2.52)	–	–
No	50,676	70	–	–	–
Total	67,791				

OR, odds ratio; CI, confidence interval.

mitigated or disappeared in the multilevel models and in those matched by the health-care institution (supplemental files 1 and 2).

Discussion

Afro-Brazilians were the majority among TB cases in Brazil in 2015. However, they had less HIV testing and mycobacterial culture performance than non–Afro-Brazilian patients. These results are consistent with other Brazilian studies that found less HIV testing among pregnant black and mixed race women;[19–21] higher rate of HIV testing among white TB patients than the other TB patient groups[9] and the lowest rate of mycobacterial culture performance among brown/mixed race TB patients.[9]

Nevertheless, the statistically significant negative association between Afro-Brazilian racial category and testing

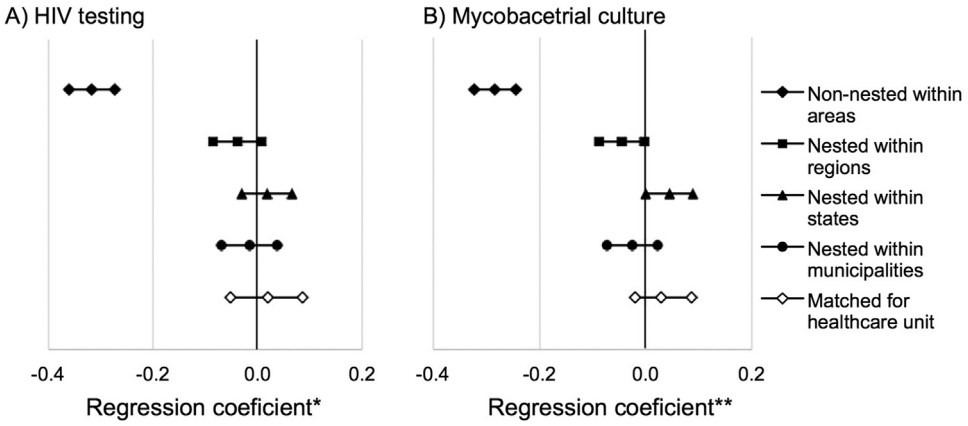

Fig. 2 – Logistic regression coefficients (with 95% confidence interval) for the relationship between Afro-Brazilian racial category and HIV testing (A) and mycobacterial culture (B), Brazil, 2015. * Coefficients adjusted for age, alcohol use disorder, clinical manifestation, prisoner and mycobacterial culture. ** Coefficients adjusted for age, sex, clinical manifestation, prisoner, HIV testing and transference.

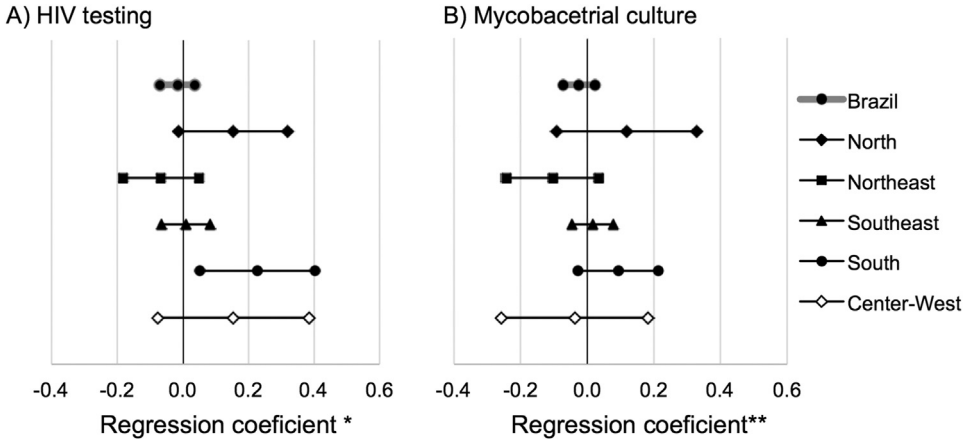

Fig. 3 – Logistic regression coefficients (with 95% confidence interval) for the relationship between Afro-Brazilian racial category and HIV testing (A) and mycobacterial culture (B), multilevel analysis of tuberculosis patients nested in municipalities by Brazilian regions. Brazil, 2015. * Adjusted for age, alcohol use disorder, clinical manifestation, prisoner and mycobacterial culture. ** Adjusted for age, sex, clinical manifestation, prisoner, HIV testing and transference.

disappeared in the analyses where patients were nested in geopolitical contexts or matched for health-care unit. It suggests that the scenarios in which the Afro-Brazilian population resides, and therefore is treated, tend to have a lower provision of the mandatory laboratory tests. In 2015, North and Northeast Brazilian states that have the highest percentage of Afro-Brazilian TB patients also concentrated the highest proportions of late HIV diagnosis,[22] which may suggest lack of access to the HIV test. Moreover, in 2014, the percentages of mycobacterial culture among previously treated TB patients in North and Northeast regions were less than 50% of that from the other Brazilian regions.[23] Therefore, the iniquity of TB patients' access to HIV testing and mycobacterial culture performance across different racial groups in Brazilian population reflects inequalities among regions with different demographic structure in implementing public health policy.[24]

Brazil has continental dimensions, and its regions have significant demographic and socioeconomic differences, such as racial composition,[5] social vulnerability, infrastructure and income.[25] Monetary or time restrictions, travel difficulties, insufficiency of professionals or information problems are obstacles in health-care access[26–28] and impacts notably North and Northeast regions.[26] Consequently, owing to geographic distribution of racial groups countrywide, the inequalities among Brazilian regions' health-care access adversely affect the Afro-Brazilian population.

In addition, the austerity policies because of the economic and political crises in Brazil impacts substantially the poorest and the most vulnerable populations and poses a major challenge for the improvement of universal health coverage.[3]

Table 2 – Factors associated to HIV testing and mycobacterial culture among tuberculosis patients, matched for health-care unit using conditional logistic regression. Brazil, 2015.

Variable	OR (95% CI)	
	HIV testing[a]	Mycobacterial culture[b]
Afro-Brazilian	1.02 (0.95–1.09)[c]	1.03 (0.98–1.09)[d]
Men		1.11 (1.05–1.17)
0–14 years old	1	1
15–39 years old	3.05 (2.63–3.54)	1.73 (1.46–2.05)
40–59 years old	2.68 (2.3–3.12)	1.78 (1.5–2.11)
60 + years old	1.57 (1.34–1.84)	1.72 (1.43–2.06)
Extrapulmonary/mixed form	1.33 (1.23–1.44)	0.44 (0.41–0.48)
Alcohol use disorder	1.19 (1.1–1.29)	
Prisoner	0.75 (0.64–0.89)	1.73 (1.49–2)
Transferred		0.86 (0.8–0.92)
HIV testing	–	1.68 (1.56–1.81)
Mycobacterial culture	1.67 (1.55–1.81)	–

OR, odds ratio; CI, confidence interval.

[a] Adjusted for race, sex, age, clinical manifestation, alcohol use disorder, diabetes, mental disorder, prisoner, transference and mycobacterial culture.

[b] Adjusted for race, sex, age, clinical manifestation, HIV testing, alcohol use disorder, diabetes, mental disorder, prisoner and transference.

[c] P 0.596; all the other associations with HIV testing had $P \leq 0.001$.

[d] P 0.249; all the other associations with mycobacterial culture had $P < 0.001$.

Other factors associated with diagnostic testing

People between 15 and 39 years old exhibited the highest chance of being tested for HIV. Because these groups are the most affected by HIV,[22] these associations may be related to a tendency of health-care providers to offer HIV testing based on their perceptions of patients' risk.[29–32] In addition, the patients' self-perceived risk may also influence the acceptance of testing.[30–34]

A higher rate of HIV testing offered to higher risk groups could also explain the positive association between testing and both extrapulmonary/mixed TB form and alcohol use disorder.[35,36] In contrast, prisoners, even having a higher prevalence of HIV infection than the general population,[37] exhibited a lower chance to be tested for HIV, such has been described in previous study.[37] It suggests that this population has insufficient access to health-care services.[17]

TB patients that had mycobacterial culture performed also had a higher chance of having a HIV test performed. It may indicate that individual or clinical factors not measured in this study, such as disease severity, can motivate concomitant testing.

Regarding mycobacterial culture, men had a higher chance of having the test performed. This result may be explained by the majority of men among priority groups for mycobacterial culture performance,[38] some of which was not considered in this study, as homelessness.[39]

Patients aged 15 years and older had a higher chance of having mycobacterial culture performed than younger patients, possibly because of paucibacillary disease and difficulty in obtaining samples from children.[40] Similarly, mycobacterial culture was negatively associated with extrapulmonary/mixed TB form, which may be related to inaccessible lesions and paucibacillary disease.[41]

The positive association between prisoners and mycobacterial culture is consistent with their prioritization to culture testing.[11,38] Despite the fact, only 44% of prisoners had mycobacterial culture performed, which is insufficient, given overcrowded confinement conditions.[38,42] Transferred cases have lower chance of having mycobacterial culture performed. However, it may denote a misregistration due to an insufficient communication between health-care units.

Limitations

Although TB notification is mandatory in Brazil[43] and the country is consistently increasing case detection and notification,[1] underreporting is a potential limitation of our study, especially if it is heterogeneous among the groups. The use of secondary data may also be a limitation of this study because of the restricted availability of variables and the potential non-uniformity of the information collection and registration. Owing to lack of data, spatial autocorrelation was not tested; nevertheless, we considered the spatial aggregation by geopolitical contexts using the multilevel analyses. The resulting estimations were consistent with that obtained in conditional models matched by health-care units.

On the other hand, some variables were not analysed because they did not have enough completeness. It has impeded the evaluation of an eventual mediation, for example, education level or homelessness in the associations found. Based on our source, it is not possible to determine the reason why HIV tests and TB mycobacterial culture are not performed. The differences we found between regions may suggest a relationship with the opportunity to get tested, but causes may include shortage of resources, poor adherence to recommendation and lack of acceptance by patients. Therefore, complementary studies would be necessary to approach elements such as patients' refusal, compliance with regulations on the part of health professionals and infrastructure.

Despite these limitations, our models were based on population data with national coverage and high completeness of the main variables. In addition, the findings are consistent with those reported in literature and provide pertinent information for decision-making in public policy. In particular, our study revealed that racial inequalities in diagnostic testing among TB patients that adversely affect the Afro-Brazilian population reflect inequalities among regions with different demographic structure.

Conclusions

In Brazil, independently of other individual variables, Afro-Brazilian patients had odds of HIV testing and mycobacterial culture which were 28% and 26%, respectively, lower than those observed in non–Afro-Brazilian patients. However, the loss of these negative associations between race and diagnosis testing, when patients were nested in geopolitical contexts or matched for health-care unit, suggests that racial inequality of TB patients' testing can be explained by the geographic

distribution of racial groups and the regional differences in diagnostic testing.

The findings of our study can support the formulation of public policies aiming to mitigate regional disparities as a strategy to improve equity in access to health-care provision. In addition, the approach presented can be applied in a range of scenarios to identify disparities, localize its source and consequently support decision-making.

Author statements

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Ethical approval

The study does not include identifiable information from tuberculosis patients, and data are publicly available in Brazil. As such, it was not necessary to submit the study to an institutional review board, which is in accordance with Resolution Nº 510 of the National Health Council of Brazil (National Health Council, Brazil, 2016).

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Competing interests

The authors declare they have no potential conflicts of interest.

Data statement

All data can be made available by Brazilian Health Ministry (http://portalsaude.saude.gov.br) on a formal request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2018.11.003.