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Area-level social development and indicators of public dental services in Southern Brazil.

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Contributions:

All authors have made substantial contributions to conception and design of the study. HG, AS, ALSFM have been involved in data collection and data analysis. HG, AS, ALSFM, DSB and MAP have been involved in data interpretation, drafting the manuscript and revising it critically and have given final approval of the version to be published.

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Abstract

Objectives: This study aimed to test associations between a municipal social development indicator and indicators of public dental services; examine differences in the achievement of public dental services goals between fluoridated and non-fluoridated municipalities; and, quantify contribution of a municipal social development indicator in estimated mean differences in the public dental services indicators between fluoridated and non-fluoridated municipalities.

Methods: A secondary analysis of data from 293 municipal dental health services records from Southern Brazil between 2010 and 2015 was conducted. Multivariable log-binomial regression models were fitted to test the associations between municipal Human Development Index (HDI) and multiple public dental services indicators (proportion of public dental health service coverage, the proportion of tooth extraction among all clinical procedures, and monthly participation in supervised tooth brushing). Cut-off points for outcomes were based on state goals for public dental services. Blinder-Oaxaca decomposition analyses were performed to quantify the relative contribution of HDI in the differences in outcomes according to the municipal water fluoridation status.

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Results: Municipalities within the lowest tertile of HDI had 66% lower prevalence of having insufficient public dental health service coverage (less than state goals)than those in the highest tertile of HDI(PR 0.44; 95%CI: 0.24, 0.50). Municipalities with lowest HDI had nearly 30% higher prevalence of failing the state goals regarding the proportion of extraction and supervised tooth-brushing (PR 1.30; 95%CI: 1.20,1.40 and PR 1.34; 95%CI: 1.23,1.45, respectively). Mean public dental health service coverage was higher in non-fluoridated municipalities than fluoridated municipalities, and municipal HDI explained 36% of the total estimated mean difference.

Conclusions: This study found associations between municipalsocial development and public dental services indicators in Southern Brazil. However, higher HDI was associated with lower public dental health service coverage, but with a higherproportion of extraction and supervised tooth-brushing. Municipal HDI contributed significantly towards the gap in public dental coverage between fluoridated and non-fluoridated municipalities, favoring non-fluoridated municipalities. These findings have important policy implications for reducing oral health inequalities as it highlights the interplay between key oral health policies and their distribution according to municipal social development.

Introduction

Oral diseases rank among the top ten global leading causes of years lived with disability[1, 2].Persistent socioeconomic inequalities in oral health outcomes and outcomes of access to oral health care are also reported across many societies[3, 4].Collectively, the two issues pose substantial challenges to countries regardless of their economic development. Arrangements of health systems specifically regarding public financing of dental services play a key role in reducing or managing the consequences of oral diseases and determining oral health inequalities[2, 3, 5]. High out of pocket payments for utilisation of dental care can significantly limit disadvantaged individuals and societies to benefit from routine and preventive dental care. Consequently, oral health inequalities within and between societies may amplify as the benefits are often skewed among socially advantaged[6]. To some extent, experts argue that extending Universal Health Coverage (UHC) to oral healthcare offers a solution to this problem[3], and the Brazilian National Health System, in principle, is a global leader in this initiative[5]. However, current high rates of tooth loss among older adults and marked socioeconomic inequalities in oral health outcomes raises concerns on its achievements[7-9].

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Social inequalities in oral health outcomes, and high disease levels among specific population sub-groups, despite the inclusion of dental care within UHC, highlights the need to better understand the role of dental care provisions. From an implementation perspective, evidence mainly from primary health care centressupports thefavourable provision of dental care in some Brazilian regions– higher accessibility in areas with high social disadvantage[10-12]Whereas, socioeconomic inequalities in use of and access to dental services at both the individual level and population level are also confirmed[7-9, 13, 14]. Therefore, evidence of the relationship between social disadvantage and oral healthcare provision and utilisation from Brazil is inconsistent.

Numerous studies show associations between indicators of area-level socioeconomic development and measures of oral health and disease within Brazil[7, 8, 15, 16]. However, fewer studies have examined the associations between oral health policies and municipal social development[11, 17, 18]. Community water fluoridation is a widely recognised public health policy for the prevention of dental caries across societies[19]. Some cities in Brazil implemented community water fluoridation as early as 1953 and mandatorily across all in 1974. Despite being recognised as equitable oral health policy, evidence shows that its implementation first benefited more advantaged than disadvantaged municipalities in Brazil[20, 21]. Intentionally, both extending UHC to oral health care and community water fluoridation are implemented for public health benefits of reduced disease levels and reduction in oral health inequalities. Based on the inequities in the implementation of community water fluoridation,[20, 21] potential concerns of inequitable distribution of provision of dental services cannot be ruled out. Collectively, the two oral health policies can also act synergistically to reduce inequalities in oral health and the burden of oral diseases. However, the role of municipal social development in variations of public dental services according to community water fluoridation status is not known. To readdress these gaps, this study aimed to test associations between municipal social development and indicators of public dental services. The second aim was to estimate variations in public dental services according to community water fluoridation status and to quantify the contribution of municipal social development in estimated differences.

Method

Study design and setting

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An ecological study was carried out using the data on public dental services from Santa Catarina State, Southern Brazil. Santa Catarina is a relatively affluent state in Brazil with a Gini index of 0.49(a widely used measure of income inequality that ranges from 0 to 1 where 0 means perfect equality and 1 perfect inequality), an illiteracy rate of 4.37% and the Human Development Index (HDI)of 0.774 compared to the average national figures of the Gini index 0.60, the illiteracy rate of 10.19%, and HDI 0.754[22]. Santa Catarina has 295 municipalities and an estimated population of about 7 million inhabitants in 2017[23].

Data Collection

Data related to the provision of public dental services were obtained from the Brazilian Unified Health System Information Database recorded between 2010 and 2015. The municipal social development indicators and sociodemographic data were obtained through the platform of the United Nations Development Program, known as the Human Development Atlas in Brazil (PNUD)[22]. Data on community water fluoridation 2010 was accessed by contacting the State Department of Sanitary Surveillance. Data on municipal social indicators were not collected for two out of 295 municipalities due to lack of reliable estimates. Therefore,these municipalities were excluded from the current analysis.

Outcomes

Key outcomes for this study were the indicators of public dental service provision in Santa Catarina State, according to the Organizational Contract for Public Action[24].(i) The proportion of public dental health service coverage: estimated population coverage of oral health teams in public services. This measure was estimated as the sum of the dentist workload in primary health care per 40 hours multiplied by 3000 inhabitants, and, divided by population size. Based on the state goals for the proportion of public coverage in 2015, this variable was dichotomized into municipalities with more than 65% coverage and municipalities with less than 65% coverage[25].(ii) The proportion of tooth extraction in the permanent dentition among all individual preventive and curative dental procedures: pattern of dental procedures performed by the public dental services, showing whether the public service is improving, focusing on prevention and treatment and having less impact on tooth loss. The proportion of tooth extraction was dichotomizedinto less than or equal to 4%/more than 4%based on the state goal[25]. (iii) Supervised collective tooth brushing: annual mean of monthly participation in collective action for supervised tooth brushing.The numerator includesthe proportion represented by the number of people taking part in the supervised

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collective tooth brushing for 12 months, and the denominator is the total population at the same place and period. This outcome was also dichotomized as less than or equal to 3%/ more than 3% based on the state goal for supervised toothbrushing[25].

Explanatory Variable

The explanatory variable was the municipal Human Development Index (HDI),a composite measure of social development. It was estimated in 2010 by the United Nations Development Programme, Institute of Applied Economic Research and Joao Pinheiro Foundation[22], using data from the last Brazilian Demographic Census[23]. It combines indices of overall population opportunity of living a long and healthy life, of accessing education, and the ability to enjoy a respectful standard of living on a decent income. Tertiles of HDI was created to allow for relative comparisons between municipalities according to the level of socialdevelopment.

Covariates

Municipal-level sociodemographic factors were considered as covariates included: the proportion of individuals over 65 years of age, the proportion of females, theproportion of rural residents,population size, municipal-level Gini coefficient as per 2010Census,andthe presence or absence of fluoridated water supply in 2010. The proportion of individuals over 65 years of age, the proportion of females, area of residence were selected as covariates based on the literature[8, 14, 20, 26]. Despite efforts to decrease the inequalities related to access and use of public dental services, social inequalities persist in the country, and more socially disadvantaged people rely on public dental services[14]. Socioeconomic and demographic conditions are also consistently associated with oral health conditions and public policies[8, 14, 20]. Data on the number of public and private supply of dentists were also collected. However, these were found to be correlated with the proportion of public dental health service coverage. Additionally, the measurement of numbers of private dentists is less reliable given that dentists may work in both public and private service, and, also across multiple municipalities.

Statistical Analysis

Pearson and Spearman´s correlation tests were applied to test correlations between continuous measures of exposure and the outcomes. Bivariate associations between the tertiles of HDI and the dichotomised outcome were tested using Chi-square test (linear-by-linear). The prevalence ratios and their 95% Confidence Interval (CI) were estimated through

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unadjusted and adjusted log-binomial regression models. Sequential adjustment of the following covariates was performed: time effect, the proportion of individuals over 65 years of age, the proportion of females, the proportion of rural residents, population size and fluoridated water supply status. The Gini coefficient was not included as a covariate for adjustment in the log-binomial regression model due to its collinearity with HDI. Long format of the outcomes, which combine all years into one variable, was applied to check the time factor. Multivariable log-binomial regression models were fitted to estimate prevalence ratios as all outcome variables had prevalence higher than 20%[27].

Furthermore, the Blinder-Oaxaca decomposition technique was performed to assess the differences in mean of public dental services outcomes according to fluoridation status. The contribution of municipal HDI to the explained differences in outcomes of public dental services between fluoridated and non-fluoridated areas was also quantified. Other covariates accounted for in the decomposition analysis included the Gini coefficient, year, the proportion of individuals over 65 years of age, the proportion of females, the proportion of rural residents and population size[28]. Positive contributions given by the determinants included in the model support the direction of the difference found in the mean value of the outcomes of public dental services between the areas. Negative contributions offset the gap measured between the areas.

The Blinder-Oaxaca decomposition explains the difference in the means of a dependent variable between two groups (in this case fluoridated and no fluoridated areas) by decomposing the gap into that part is due to differences in (i) the mean value of the independent variable within the groups, (ii) group differences in the effect of the independent variable. The components of the Blinder-Oaxaca decomposition are described as R=E+C+I- differences in predictors due to the group, differences in coefficients and the interaction term, where:

E: is the endowment term. This is the contribution of differences in the explanatory variables across groups;

C: is the coefficient. It informs that the groups differ from one another by the value of the coefficient;

I: is the interaction. This indicates the interaction across group difference among the independent variables and coefficients simultaneously.

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Results

Table 1 displays the characteristics of the studied variables. All municipalities in this study had at least one oral health team (a dentist with or without an assistant) in the public service from 2011 to 2015. The proportion of municipalities covered by fluoridated water supply in 2010 was 75%.Median population across municipalities was 7500(Table 1).Mean values of public dental health service indicators between 2010 to 2015 were 85.6% for public dental coverage, 8.4% the proportion of tooth extraction among all the clinical procedures, and 2.6% for supervised tooth brushing.

Table 2 shows that 40% of the municipalities with more than 65% of public dental health service coverage were included in the lowest group of HDI. However, the lowest HDI group had almost double the proportion of tooth extraction in the permanent dentition than the most developed municipalities (10.8%vs 6.4%). They also had the lowest mean of supervised tooth brushing procedures (2.2%). Municipalities that achieved the state goals for the proportion of extraction (≤4%), and supervised tooth brushing (>3%) ,were concentrated in the higher HDI group (49.2%; 42.4%, respectively).

Unadjusted estimates from the multivariable log-binomial regression models showed that there was a significant difference in the public dental service outcomes prevalence ratios within three groups of HDI (Table 2). The municipalities within the lowest tertile of HDI had 86% (PR 0.14, 95%CI 0.09, 0.20) lower prevalence of having less than 65% of public dental health coverage than those in the highest HDI tertile. Whereas, municipalities in the lowest tertile of HDI had 29% (PR 1.29 1.20-1.39) higher prevalence of having more than 4% proportion of extraction and 21% (PR 1.21, 1.13-1.30) higher prevalence of having less than 3% supervised tooth brushing, respectively. After adjustment, the lowest HDI group estimate for public dental health service coverage outcome reduced to 66% (PR 0.34 0.24, 0.50) lower prevalence of not achieving the state goal than the better-off municipalities. No variations in associations between municipal HDI and the outcomes of the proportion of extraction and supervised tooth brushing were observed upon adjustment of covariates.

Significant differences in the mean of public dental health service coverage outcome were found according to municipal-level water fluoridation status (Table 3). The differences in mean were not statistically significant for outcomes of the proportion of extraction and supervised tooth brushing (not reported in tables, reported as a supplementary file). The

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adjusted analyses showed that non-fluoridated areas had an average coverage of 93% and fluoridated areas had85% coverage. The mean difference in public dental service coverage between non-fluoridated and fluoridated areas was approximately10% (95%CI 7.70, 11.48). Of the observed mean difference, 53.6% could be explained by the predictors included in the model, but 46.4% of the difference remained unexplained. In other words, if the covariates were to be distributed equally between fluoridated and non-fluoridates areas, the difference would have been 5.14 points lower (53.6%). HDI's contribution to the explained mean difference inpublic dental coverage according to water fluoridation status was 36% favouring non-fluoridated areas(Table 4).

Discussion

Higher municipalsocial development was associated with lower public dental health service coverage. However, higher municipalsocial development was associated with a lower proportion of extraction and a higher proportion of supervised tooth brushing. Decomposition analysis showed that municipal HDI explained approximately one-third of the total difference in public dental coverage between non-fluoridated and fluoridated municipalities.

The present study has several strengths and some weaknesses. There are some criticisms regarding the public dental service indicators[11, 29]. The current study is based on state goals for the year 2015.These goals lack supporting evidence to prove their accuracy and relevance. Moyses[29]highlighted some limitations of using public dental service provision indicators that are currently applied in Brazil. They primarily fulfil purposes of monitoring of services and are incapable of reflecting underlying inequalities by socioeconomic status and demographic characteristics. They are not comprehensive in their intent and are limited designed to overcome the programmatic/management challenges. These indicators are also in sensitive to vulnerable population groups and do not capture their history of illness or practices of healthcare seeking that may assist in targeting specific population groups with high and unmet needs. Therefore, their application is limited to health managers for monitoring the progress of access to dental public service, and service improvement, through patterns of preventive services over years[24].

The ecological design does not allow individual-level inferences[30]. Therefore, it is inappropriate to infer from this study thatsocially disadvantaged individuals benefit from the higher provision of public dental services according to area disadvantage. Additionally,

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causal inferences on the association between HDI and the public dental service indicators cannot be made based on the current findings. Furthermore, like any secondary analysis, data inaccuracies from different data sources cannot be ruled out[11, 17]. Despite improvements in the Brazilian Health Information Systems, effective policies to improve the coverage and quality of health information systems and administrative data are needed. Data may vary substantially across the health information systems[31]. However, the methodology used is justified and appropriate when there is an interest in studying the impact of public policies such as the provision of public dental services and the water fluoridation[30, 32]. The relative contribution of HDI to predict the public dental service outcomes and the observed difference in these outcomes between fluoridated and non-fluoridated areas is a key innovative feature of this study.

Greater availability of public dental health service coverage was observed in lesser developed municipalities; contradictorily, these municipalities did not achieve their goals of demonstrating a preventive pattern of dental services (lower proportion of extraction and a higher proportion of supervised tooth brushing). Previous findings pointed out a lower preventive pattern of dental services in less developed municipalities and also reported a higher proportion of tooth extraction among rural residents in the three states of the Southern Brazil[18].Rural residents and more disadvantaged people are affected more by dental caries, and tooth loss in Brazil.[26]Social inequalities in oral health are reported almost universally[4]. Furthermore, studies highlight that water fluoridation, a widely acknowledged public policy for prevention and reduction of dental caries and its negative consequences[19, 33], has delivered early and higher benefits to better-off municipalities in Santa Catarina state and nationally[20, 21].

Previous examination of associations between state-level HDI and public dental service indicators have shown negative correlations with the outcomes of public dental health service coverage and lack of association with outcomes of supervised tooth brushing[11].Besides, studies[12, 34] have shown that the expansion of primary health care provision[12, 35]and also public dental services based on primary health care centres[10, 11, 17, 36] aim to reach out to the poorest areas and vulnerable people. The findings of the present study substantiate these findings regarding the outcome of public dental health service coverage. Public dental services provided through primary health care centres are also shown to promote use by women, older people, unemployed and other socially disadvantaged population

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groups[10,12,14,34,36]. However, a generalisation of these findings to other outcomes of public dental services should be avoided as noted with the outcomes of the proportion of extractions and supervised tooth brushing in the current study. Social inequality in the use of and access to dental services has also been confirmed in both public and private services[9, 13, 14].

The decomposition analysis showed that HDI substantially explained the difference in public dental coverage according to area-level water fluoridation. Compared to the fluoridated municipalities, the public dental coverage was higher in non-fluoridated municipalities, and HDI was identified as a substantial contributor to the observed difference. Overall, the higher presence of public dental coverage in non-fluoridated areas could be likely due to higher levels of oral disease, consequently more demand and pressure for dental services. Within Brazil, studies have shown that the implementation of community water fluoridation first benefitted areas with higher HDI than areas with lower HDI[20, 21, 37]. The decomposition analysis has shown that mean variation in public dental coverage according to community water fluoridation are largely accounted to municipal social development position (HDI), and not through populations' demographic composition. However, the proportion of rural residents were able to explain 24% of the difference between the mean of public dental health coverage in fluoridated and non-fluoridated areas. Rural areas are known for being more vulnerable, with lower development, and for having a higher frequency of tooth loss and lower fluoridated water supply coverage[18,26]. Therefore, based on existing evidence of 'inverse equity hypothesis' related to community water fluoridation in Brazil, reduction in area-level social inequalities in oral health needs careful assessment of the interplay between social disadvantage, oral health policies including water fluoridation and availability of public dental services. This study was not powered sufficiently to analyse whether public dental health service coverage was equitably distributed within fluoridated and non-fluoridated areas.

In conclusion, the municipal HDI was associated with outcomes of public dental services and significantly explained the difference inthe public dental coverage between fluoridated and non-fluoridated areas. Current approaches to dealing with the overall burden of oral diseases are effective but have a limited impact in addressing oral health inequalities[4]. Evidence on their cost-effectiveness for tackling the two-pronged objectives of reducing overall burden as well as oral health inequalities is also less known[4]. Further investigations are required to assess the effect of oral health policies on reducing oral health inequalities.

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Table 1Descriptive statistics of municipal sociodemographic characteristics, social development indicators andindicators of public dental services inSouthern Brazil 2010-2015.

		Mean (SD)	% (SD)	Range	Median
HDI (Continuous)		0.7 (0.0)		0.6, 0.8	0.7
Gini coefficient 2010		0.4 (0.0)		0.2, 0.6	0.4
Sex	Proportion of males		50.6 (1.3)	47.5, 63.5	50.6
	Proportion of females		49.3 (1.3)	36.4, 52.4	49.4
Age	Proportion aged 65 and above		8.2 (1.8)	4.1,13.5	8.3
Type of area	Proportion of Urban residents		59.1 (23.9)	14.1, 100.0	57.4
	Proportion of Rural residents		41.3 (23.6)	1.2, 85.9	43.1
Population size 2010		21325.7 (50687.1)		1465, 515288	7458
Fluoridated water supply 2010 (FWS)	Percentage of municipalities with FWS		75.1		
Public dental health coverage					
	Proportion of public dental services - 2010		84.3 (22.8)	0.0, 100.0	100.0
	Proportion of public dental services - 2011		85.0 (21.9)	21.3, 100.0	100.0
	Proportion of public dental services - 2012		85.8 (21.3)	23.8, 100.0	100.0
	Proportion of public dental services - 2013		85.9 (21.3|)	17.0, 100.0	100.0
	Proportion of public dental services - 2014		86.5 (20.1)	23.2, 100.0	100.0
	Proportion of public dental services - 2015		86.0 (20.3)	23.6, 100.0	100.0
	Proportion of public dental services – 2010-2015		85.6 (20.1)	26.6, 100.0	97.9
Proportion of extraction	Proportion of extraction - 2010		9.6 (7.6)	0.0, 51.1	7.8
	Proportion of extraction – 2011		9.1 (9.3)	0.0, 96.0	7.2
	Proportion of extraction – 2012		9.2 (9.2)	0.0, 100.0	7.1
	Proportion of extraction – 2013		7.8 (7.7)	0.0, 86.4	6.4

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	Proportion of extraction – 2014	7.5 (5.7)	0.0, 32.5	6.2
	Proportion of extraction - 2015	8.2 (9.7)	0.0, 100.0	6.0
	Proportion of extraction – 2010-2015	8.4 (5.7)	0.0, 37.8	6.9
Supervised tooth brushing (STB)	Proportion of STB - 2010	2.6 (4.6)	0.0, 42.5	0.8
	Proportion of STB – 2011	2.6 (4.2)	0.0, 34.8	0.8
	Proportion of STB – 2012	2.7 (4.2)	0.0, 31.9	0.9
	Proportion of STB – 2013	2.7 (4.9)	0.0, 44.1	0.9
	Proportion of STB – 2014	2.5 (4.1)	0.0, 33.9	0.7
	Proportion of STB - 2015	2.5 (4.7)	0.0, 43.6	0.7
	Proportion of STB – 2010-2015	2.6 (3.6)	0.0, 30.4	1.2

FWS: Fluoridated water supply. STB: Supervised tooth brushing

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Table 2. Associations between municipal HDI and outcomes of public dental services

		N (%)	Range	Public dental coverage (Ref: >65%)			Proportion of Extraction (Ref: <=4%)			Supervised tooth-brushing (Ref: >3%)		
				N(%)[1]**	Unadjusted	Adjusted[2]	N(%)[1]**	Unadjusted	Adjusted[2]	N (%)[1]*	Unadjusted	Adjusted[2]
					PR (95% CI)	PR (95% CI)		PR (95% CI)	PR (95% CI)		PR (95% CI)	PR (95% CI)
HDI	High	94 (32.1)	0.75,0.84	62 (25.9)	1	1	31 (49.2)	1	1	36 (42.4)	1	1
	Medium	101(34.5)	0.71,0.75	82 (34.3)	0.5 (0.4, 0.6)	0.7 (0.6;0.8)	23 (36.5)	1.1 (1.1,1.2)	1.1 (1.0,1.2)	29 (34.1)	1.1 (0.9,1.1)	1.1 (1.1,1.2)
	Low	98 (33.4)	0.62,0.71	95 (39.7)	0.1 (0.1,0.2)	0.3 (0.2;0.5)	9 (14.3)	1.3 (1.2,1.4)	1.3 (1.2,1.4)	20 (23.5)	1.2 (1.1,1.3)	1.3 (1.2,1.4)

[1]Chi-square (linear-by-linear) * p≤0.05 **p≤0.01. [2]Adjusted for year effects, proportion of adults over 65 years of age, proportion of females, proportion of rural residents, fluoridated water supply and the population size from Census 2010; PR: Prevalence Ratio;

Table 3. Decomposition of the public dental coverage between fluoridated and non-fluoridated municipalities

	Public dental coverage (95%CI)	*p*-value
Non-fluoridated area	93.1 (91.6,94.6)*	<0.001
Fluoridated area	83.5 (82.3,84.7)*	<0.001
Difference Coefficient	9.5 (7.7,11.5)*	<0.001
Explained	5.1 (4.1,6.1)*	<0.001
Explained (%)	53.6*	
Unexplained	4.4 (2.7, 6.2)	<0.001

*Adjusted analysis

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Table 4. Explained component of the public dental health service coveragebetween fluoridated and non-fluoridated municipalities obtained by decomposition analysis

	Public dental coverage *		
	Coefficient (95% CI)	*p*-value	Proportion explained (%)
Covariates			
Year	0.0 (-0.1,0.1)	1.000	
Gini coefficient	0.1(-0.1,0.4)	0.199	
HDI	1.8 (1.2,2.5)	<0.001	35.8
Proportion of rural residents	1.2(0.5,1.9)	<0.001	24.1
Proportion of adults over 65yo	-4.2 (-9.1,0.5)	0.082	
Proportion of females	-28.5(-93.2,36.0)	0.386	
Population size 2010	34.76 (-26.5,96.1)	0.266	

*Adjusted analysis

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