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The Role of Socioeconomic and Health Services Organizational Factors on Infection Control Structure Score, Brazil

O Papel dos Fatores Socioeconômicos e de Organização dos Serviços de Saúde sobre o Escore da Estrutura de Controle de Infecção, Brasil

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Abstract *This study aimed to analyze possible associations between the Infection Control Structure Score (ICSS), health services, and social characteristics of the municipalities in Brazil. Secondary data from the third cycle 2017-2018 of the Brazilian National Program for Improving Primary Care Access and Quality (PMAQ) was analyzed. Six independent variables – FIRJAN Index of Municipal Development, number of inhabitants, number of family health teams receiving a financial incentive from the federal government, healthcare expenditure per capita, and number of Oral Health Teams modalities 1 and 2 – were included to assess their influence on ICSS, measured for each Brazilian town. Data analysis used the Classification and Regression Tree model performed with IBM SPSS 25. A total of 4,900 municipalities were included, and the mean ICSS was 0.905 (±0.092). A positive relationship was observed between healthcare expenditure per capita, municipal development, and the outcome. Conversely, towns with a higher number of family health teams receiving a financial incentive from the federal government showed lower mean ICSS. The findings suggest that inequalities in the infection control structures exist within the country, and they were related to the health services and social characteristics of the municipalities.*

Key words *Infection control, Dental care, Primary Health Care*

Resumo *Este estudo objetivou analisar as possíveis associações entre o Escore da Estrutura de Controle de Infecção (EECI), os serviços de saúde e características sociais dos municípios brasileiros. Foram analisados dados secundários do terceiro ciclo 2017-2018 do Programa Nacional de Melhoria do Acesso e Qualidade da Atenção Básica (PMAQ). Seis variáveis independentes – Índice FIRJAN de Desenvolvimento Municipal, número de habitantes, número de Equipes de Saúde da Família que recebiam incentivo financeiro do governo federal, gasto com saúde per capita e número de Equipes de Saúde Bucal modalidades 1 e 2 – foram incluídas para avaliar a influência sobre o EECI, medido para cada município brasileiro. Para a análise dos dados, foi utilizado o modelo de Árvore de Classificação e Regressão no IBM SPSS 25. Foram incluídos 4.900 municípios, e o EECI médio foi de 0,905 (±0,092). Observou-se uma associação positiva entre o gasto com saúde per capita, o desenvolvimento municipal e o desfecho. Por outro lado, municípios com maior número de Equipes de Saúde da Família com incentivo financeiro do governo federal apresentaram menor média do EECI. Os achados sugerem que existem desigualdades nas estruturas de controle de infecções no país, relacionadas aos serviços de saúde e às características sociais dos municípios.*

Palavras-chave *Controle de infecções, Assistência odontológica, Atenção Primária à Saúde*

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Introduction

In dental practice, both patients and providers are susceptible of being infected by pathogenic microorganisms, such as Hepatitis B virus, Mycobacterium tuberculosis, and SARS-CoV-2[1-3]. This is critical within the dental environment by reasons of the routine usage of ultrasonic instruments, and high-speed handpieces during many oral procedures, which create airborne bioaerosols and droplets, that might be a source of transmission to pathogens[1,3]. Furthermore, contaminated instruments, equipment, and surfaces that are frequently touched by dental staff may also be a vehicle of infection[1,3]. Early investigations, conducted in different locations, found that dental visits were a significant risk factor for the transmission of Hepatitis B, and Hepatitis C virus[4-6].

Healthcare-associated infections (HAI) are frequent adverse events at the point of care delivery contributing to morbidity, mortality, and have a substantial economic burden on overall society, especially in developing countries[7]. Fortunately, many HAI are evitable through adequate physical structure, awareness, and adherence to effective Infection Prevention and Control (IPC) practices[8]. This is corroborated by a longitudinal study conducted in a Brazilian dental school during the pandemic of coronavirus disease 2019 (COVID-19). It was found that a low number of dental staff 5.8% (n=6/103) and patients 0.9% (n=1/105) tested positive for SARS-CoV-2 during the study period[9]. A similar pattern was seen in primary dental care services in the United States[10]. As such, dental practice might be safely executed when tight compliance to biosafety protocols is applied.

Due to the pandemic of COVID-19, comprehensive discussions about IPC took place in the scientific community, and numerous guidelines, protocols, and research papers on this topic were published[11-15]. These documents underline the need to strengthen IPC practices, particularly in Primary Health Care (PHC). According to Starfield *et al.*[16], PHC may account for several benefits on population health, such as great access to needed services, better quality of care, greater focus on prevention, early detection and management of diseases, and reduction of unnecessary specialized care. Under those positive aspects, PHC seems an important level of care to health systems.

Aiming to improve access and quality of services provided at PHC, the federal government, between 2011 and 2018, funded three cycles of the Brazilian National Program for Improving Primary Care Access and Quality (PMAQ, in Portuguese). The foundation of the program relied on the quality-of-care framework proposed by Donabedian, in which quality is related to structure, process, and outcome parameters[17]. PMAQ was a public sector assessment of PHC facilities, compliance with the program was voluntary, and its main goal was to strengthen PHC by allocating financial resources from the Ministry of Health to municipalities based on the performance of primary care workers[18]. PMAQ was terminated by the federal government in December 2019, establishing new bases for PHC funding[19].

Previous analysis of data from the second evaluation cycle of PMAQ revealed that only 1.3% (n=208) of all evaluated dental clinics, complied with all of the infection control items assessed in the study[20]. Additionally, of the Brazilian regions, South and Southeast showed a better structure of infection control in dental clinics[20]. Further investigations, using data from the third cycle of PMAQ demonstrated that inequalities in the structure of infection control within the country persisted. That is, the South region had the best infection control structure, while the North region had the worst structure[21].

Evidence suggests that characteristics of health services and local social factors may impact the performance of public dental clinics[22-24]. Machado *et al.*[22], pointed out that different forms of organization of work processes and, contextual characteristics of the place where the services were implanted, such as population size, municipal human development index, and primary healthcare coverage influenced the performance of oral health services. Coincidently, a multilevel analysis reported that organizational variables of the Brazilian dental services (dental appointment during pregnancy; delivery of home dental care; usage of guidelines for prostheses; referral for secondary care), and better socioeconomic status were positively associated with better performance of dental services[24]. In this context, we have the hypothesis that social characteristics of the municipalities (FIRJAN Index of Municipal Development [FIMD], and number of inhabitants), and health service organizational factors (number of family health teams receiving financial incentives from federal government, healthcare expenditure *per capita*, and number of Oral Health Teams [OHT] modalities 1 and 2) may influence the standards of infection control.

In a previous study, the development of an Infection Control Structure Score (ICSS) was pre-

sented for OHT in the Brazilian PHC[21]. Although preliminary studies reported inequalities related to infection control, the associated factors are not known. Hence, this study aimed to analyze possible associations between ICSS, health services, and social characteristics of the municipalities in Brazil.

Materials and methods

Ethics Statement

This study analyzed a publicly available database from the Brazilian Ministry of Health, which was approved by an Ethics Committee on Research involving human beings (CAAE 77847417.9.0000.0055; Approval number 234 6623).

Study design

This is a health evaluation study that analyzed secondary data from the third evaluation cycle (2017-2018) of the PMAQ. During the third cycle of the program, the evaluation of PHC units comprised of self-assessment of the teams, routine monitoring, and external evaluation. All the questions included in this study were obtained from the external evaluation phase of the program, which was produced by the Ministry of Health together with some national research institutions. The external evaluation consisted of collecting data about access and quality of PHC units, and the instrument used was structured with 903 questions[25].

Of the 22,046 PHC units, 1,745 were excluded for the following reasons: unit deactivated; management did not authorize the evaluation of the unit; the OHT did not authorize assessment; the unit was undergoing remodeling or expansion and the staff was not delivering care anywhere else; the team did not adhere to PMAQ; the OHT permanently works elsewhere; the OHT works with a specific population (remote area, penitentiary system, and mobile team). Thus, 20,301 PHC units with OHT were included in this study.

Study variables

In our analysis, the outcome variable was the ICSS for each Brazilian municipality measured by 14 items related to the equipment and physical structure of the dental offices in the PHC units: 1) Good ventilation or air conditioning (yes, no); 2) Floor and walls with washables surfaces (yes, no); 3) Mold near sink (yes; no); 4) Faucet without running water (yes, no); 5) Pungent sewage smell (yes, no); 6) Lack of water (yes, no); 7) Autoclave in use (none, one or more); 8) Pack sealer in use (none, one or more); 9) Touchless sink faucet (none, one or more); 10) Sharp container (yes, no); 11) Rubber gloves for cleaning dental instruments (yes, no); 12) Materials/products for cleaning dental instruments and drills (yes, no); 13) Products for packaging dental instruments for sterilization (yes, no); 14) Personal protective equipment (safety glasses, surgical gloves, and masks) in sufficient quantity (yes, no). No missing data were identified for these 14 variables. Each PHC unit received an ICSS score. Higher values indicated better structure for infection control. The full description of the score was published elsewhere[21].

The independent variables included in the study were organized into two main groups: Social characteristics of the municipalities (FIMD, and number of inhabitants), and Health service organizational factors (number of family health teams receiving financial incentives from the federal government, healthcare expenditure *per capita*, and number of OHT modalities 1 and 2). All these variables were numeric, either discrete or continuous, measured at the municipal level and collected from official Brazilian government databases (Chart 1).

Statistical analysis

Initially, descriptive statistics were performed for both outcome and independent variables to estimate frequencies and variability. Next, Classification and Regression Tree (CaRT) analysis was deployed.

CaRT is a nonparametric statistical approach that is valuable for analyzing complex data, and usage has been growing in health sciences, and epidemiological research[26,27]. This method can effectively identify subgroups within a population whose members have similar characteristics that influence the outcome variable[26,27]. The result of CaRT is illustrated by an informative hierarchical chart, called decision tree, which is composed of a parent node – a group containing the entire sample – that branches into multiple descendent nodes, according to the independent variable with the strongest interaction to the outcome. At the point that no further subdivision is feasible, a terminal node is created[26]. The advantage of using CaRT in public health studies is that iden-

Chart 1. Description of the independent variables.

Variables	Description	Reference year	Source
Social characteristics of the municipalities			
FIRJAN Index of Municipal Development	A summary measure developed to annually monitor the socioeconomic development of all Brazilian municipalities taking into account three dimensions: employment/income, education, and health. Range 0 to 1 - the closer to 1 the greater municipal development.	2018	FIRJAN
Number of inhabitants	Annual estimate of the total population according to all Brazilian municipalities with reference date on July 1st.	2017	IBGE
Health service organizational factors			
Number of family health teams receiving financial incentive from federal government	In Brazil, family health teams are the main responsible in providing PHC to the population. These teams are composed of at least one physician, a nurse, a nurse assistant, and community health agents.	2017	DATASUS
	This variable refers to the number of family health teams receiving resources from the Brazilian Ministry of Health. It is expected that municipalities with higher number of teams being funded have greater condition to organize the physical and organizational structure, equipment, supplies and human resources in the PHC units.		
Healthcare expenditure *per capit*a	The amount, in Brazilian reais, which corresponds to public and private spending on health goods and services, per inhabitant per year.	2017	DATASUS
OHT modality 1	Number of teams composed by one dental practitioner, one oral health assistant or technician who worked in the Brazilian PHC.	2018	DATASUS
OHT modality 2	Number of teams composed by one dental practitioner, one oral health assistant, and one technician who worked in the Brazilian PHC.	2018	DATASUS

Note: DATASUS = Department of Informatics of the Brazilian National Health System; FIRJAN = Federation of Industries of the State of Rio de Janeiro; IBGE = Brazilian Institute of Geography and Statistic; OHT = Oral Health Teams; PHC = Primary Health Care.

Source: Authors.

tifying high-risk population subgroups could be helpful to target interventions, and consequently reduce health disparities[26,27].

For this study, CaRT model was composed of a numeric continuous outcome variable and other six numeric independent variables The outcome was the average value for ICSS for each Brazilian municipality. Initially, mean, and median ICSS were tested to aggregate the indicators of the dental units in each municipality. The median showed a pronounced left asymmetry (negative asymmetry), then the mean ICSS was selected to run CaRT model. The Chi-square Automatic Interaction Detection (CHAID) method was used to perform successive divisions of the database. For each division, CHAID method automatically selected cutoff points for the covariates that interacted with the outcome (ICSS)[28]. Some splitting criteria were established to develop CaRT: (1) each node should have at least 50 observations to perform subdivisions; (2) each terminal node should have at least 30 observations; (3) the model disregards subdivisions with $p \geq 0.05$[28]. All statistical analysis was performed using SPSS software version 25 (SPSS Inc., Chicago, USA).

Results

Of the 5,570 municipalities in Brazil, a total of 670 (12.02%) were excluded from analysis because, by the time of the third evaluation cycle of PMAQ (2017-2018), they did not have any implemented PHC unit. The final sample consisted of 4,900 municipalities, which ICSS, social characteristics and health service organizational factors are shown in Table 1.

The CaRT generated a tree containing 14 nodes (Figure 1). The average ICSS ranged from 0.853 (±0.108) to 0.943 (±0.074) between the

nodes. The first variable selected for splitting was healthcare expenditure per capita creating seven nodes (N1-N7). Municipalities that spent more money on care delivery showed high ICSS. Among those municipalities where expenditure *per capita* was $221.0-318.3 (N3; n=984), FIMD provided the most significant split, and two terminal nodes were created. The subgroup that FIMD was ≤0.579 presented low ICSS (mean=0.877 ±0.101; n=309), when compared to the subgroup with FIMD >0.579 (mean ICSS=0.899 ±0.080; n=675). FIMD also interacted with the group of municipalities, which expenditure *per capita* was $318.3-446.3 (N4; n=979), resulting in three terminal nodes. These nodes demonstrated that high FIMD is positively associated with ICSS. Fi-

Table 1. Description of ICSS, social and health service organizational factors from 4,900 Brazilian municipalities.

Variables	Minimum	Mean	Median	Maximum
ICSS	0.32	0.91	0.93	1.00
FIRJAN Index of Municipal Development	0.32	0.66	0.67	0.88
Number of inhabitants	812	38,508.67	11,837	12,106,108
Number of family health teams receiving financial incentive from federal government	1.00	18.05	6.00	5,688
Healthcare expenditure *per capita*	67.54	449.76	382.00	2,764.19
OHT modality 1	0.00	4.57	3.00	247.00
OHT modality 2	0.00	0.44	0.00	206.00

Note: ICSS = Infection Control Structure Score; OHT = Oral Health Team.

Source: Authors.

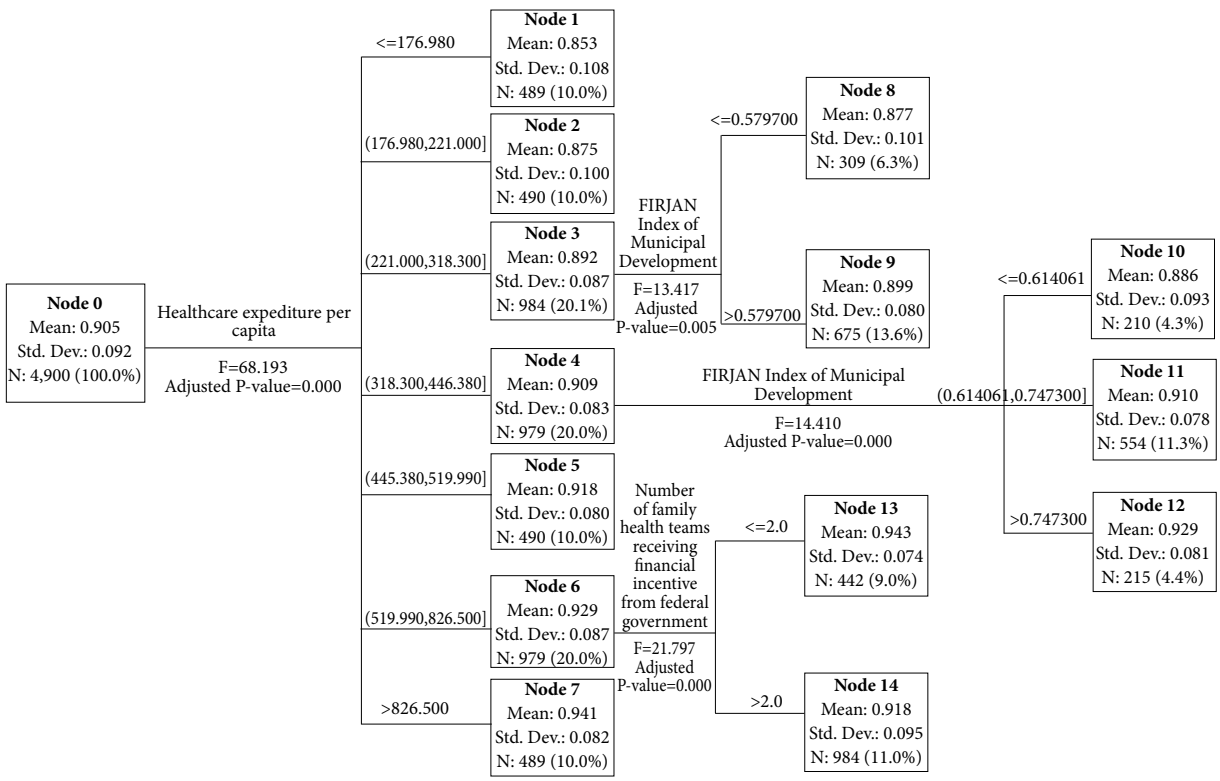

Figure 1. Regression tree of ICSS according to independent variables.

Source: Authors.

nally, among the 20% of municipalities that had the second highest range of healthcare expenditure (N6; n=979), the variable number of family health teams receiving financial incentives from the federal government influenced the outcome, but in an inverse way. That is, municipalities with more than two family health teams receiving financial incentives had lower ICSS indicators.

Discussion

In this study, we could identify significant inequalities in the structure of infection control across the Brazilian municipalities, as well as the three main associated factors. A positive relationship was observed between healthcare expenditure per capita, FIMD, and the outcome. Conversely, municipalities with higher number of family health teams receiving financial incentives from the federal government showed lower mean ICSS.

The findings of this research suggest that the financial resources spent per person per year in care delivery dramatically impact the structure of IPC. This trend is somehow similar to other countries. In the United States, the sum of money spent per individual with healthcare increased from $5,259 in 1996 to $9,655 in 2016[29]. This substantial growth improved the general quality of healthcare including biosafety in care facilities, resulting in the overall reduction of HAI[30-34]. The incidence of some infections caused by multidrug-resistant microorganisms, such as Methicillin-resistant *Staphylococcus aureus* considerably decreased in recent years[35,36]. Additionally, the Centers for Disease Control and Prevention (CDC) reported that the national percentage of central-line bloodstream infections dropped by 50% between 2008 and 2014[33]. Besides that, health systems from low and middle-income nations like Brazil, usually have tight budgets, then basic structure and supplies (e.g., safe water supply, autoclaves, antiseptics, surgical gloves, gowns, and safety goggles) might be irregularly available, making IPC a challenge[37]. Therefore, to advance the standards of infection control in Brazil, authorities should deploy some schemes to expand healthcare expenditure per capita, especially in the more vulnerable municipalities.

Locations with great economic development, measured by the FIMD, presented high ICSS. Brazil is marked by profound socioeconomic inequalities within the country[38-40]. Typically, the South and Southeast geographic regions are the most developed, consequently, they present better health outcomes, PHC performance, and quality of care delivered[41-43]. A previous study conducted at the regional level reported that the most affluent Brazilian regions had better structure of infection control in dental offices[20]. Our results highlight that this pattern remains at the municipal level, mostly because the top-ranked towns, according to the FIMD, are in the South and Southeast[44]. Other few surveys have considered the relationship between economic areas of outpatient settings, and IPC practices. Qiao *et al.*[45] assessed 146 facilities, including hospitals, and community centers in five Chinese provinces regarding the infrastructure, apparatus, materials, and basic activities of IPC. The authors found out that local development and local Gross Domestic Product were positively associated with better structure of infection control[45]. Similarly, Cleveland *et al.*[46], found that implementation of IPC recommendations in dental clinics varied across United States Census division; those located in rural regions had low rates of compliance with IPC guidelines. Public attempts should be made by the federal, state, and local governments to establish policies to strengthen IPC processes or practices.

Surprisingly, towns, where more family health teams received federal resources, had worse average ICSS. This finding is interesting since it is expected that towns with higher number of teams being funded should have greater conditions to organize the physical and organizational structure, equipment, supplies, and human resources for infection control in PHC units. A possible explanation for this finding may be the fact that there is more implantation of family health teams in municipalities with lower income, geographically and economically less favorable. More vulnerable regions may face fragilities in the physical structure, equipment, and supplies for infection control, and lack of personal protective equipment for practitioners[21]. However, this relationship is not entirely clear, and our results must be interpreted with caution. Thus, further primary studies are needed to understand this topic fully.

The current study has some drawbacks that should be addressed. First, secondary databases have some inherent limitations, such as missing information. Although 1,745 (7.9%) PHC units were excluded from our analysis, PMAQ collected data in almost 88% of the towns participating in the third cycle covering all five Brazilian geographical regions. In addition, it is pertinent to take into consideration the great complexity of

the PMAQ scheme rolled out in Brazil, which is one of the largest pay-for-performance programs in the world[47]. Second, the cross-sectional design of this survey does not allow the establishment of causal relationships, but rather associations. Third, compliance to PMAQ was not compulsory, then municipal management could have subscribed just some of the OHT, which may have biased the results. Despite that, PMAQ dataset is a relevant and robust source of data for PHC analysis at the national level.

Based on the results of this study, it could be concluded that those municipalities with higher healthcare expenditure per capita and, municipalities with higher degrees of development, measured by FIMD, showed better ICSS. On the other hand, towns with a higher number of family health teams receiving financial incentives from the federal government showed lower ICSS. As such, it seems that the health services and social characteristics of the Brazilian municipalities are associated with the structure of infection control in PHC.

Albeit accumulated evidence is necessary to understand this topic fully, our findings may bring some theoretical and practical implications to overcome the issue of infection control in dental primary care. To advance, political will and some schemes to expand fund-raising to healthcare are necessary. It is well documented that increasing healthcare resources is a relevant strategy for improving access, work processes, health outcomes, and the standards of infection control[29, 30, 48, 49]. Also, we observed that municipal development was linked to the outcome. As such, broad policies focusing on general municipal development might indirectly improve the structure in the towns and, consequently narrow inequalities related to the structure of infection control.

Collaborations

EP Fonseca, EA Pereira-Júnior, AC Palmier, and MHNG Abreu were responsible for designing the research project. EA Pereira-Júnior, and MHNG Abreu performed data analysis and interpretation. EP Fonseca, AJS Cruz, AC Palmier, EA Pereira-Júnior, and MHNG Abreu, performed the writing and critical review of the manuscript; all authors approved the final version.

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