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Factors associated with the use of a public information system of dentist-prescribed antibiotics in Minas Gerais, Brazil

Fatores associados ao uso de um sistema de informação público de antibióticos prescritos por cirurgiões-dentistas em Minas Gerais, Brasil

Jacqueline Silva Santos (https://orcid.org/0000-0003-0572-4668) [1]
Alex Junio Silva Cruz (https://orcid.org/0000-0003-1905-4124) [1]
Cristina Mariano Ruas (https://orcid.org/0000-0003-0275-8416) [2]
Edmilson Antônio Pereira Júnior (https://orcid.org/0000-0003-2837-4744) [3]
Flávio Freitas Mattos (https://orcid.org/0000-0002-6052-2762) [4]
Monina Klevens (https://orcid.org/0000-0003-2073-5576) [5]
Mauro Henrique Nogueira Guimarães Abreu (https://orcid.org/0000-0001-8794-5725) [4]

Abstract *This article aims to investigate the association between socioeconomic factors, health care organizations, and the use of a management and monitoring system for the dispensing of antibiotics prescribed by dentists in public health services in Minas Gerais, Brazil. This is an ecological-epidemiological study that analyzed secondary data from the Integrated Pharmaceutical Care Management System (SIGAF) of the Department of Health of the state of MG, Brazil, in 2017. Thirteen independent variables were analyzed to assess their influence on municipal adherence to SIGAF system considering dental prescriptions of antibiotics. Descriptive statistical analyses were performed, and the Classification and Regression Tree technique was used to identify the municipal variables associated with the outcome. A total of 57,279 antibiotic courses prescribed by dentists and recorded in SIGAF were examined. Socioeconomic factors were not associated with the use of SIGAF to record these prescriptions. Oral healthcare coverage was positively associated with the use of SIGAF for the dispensing of antibiotics prescribed by dentists. Dental Specialties Center were negatively associated with the outcome. Municipalities with high oral healthcare coverage and those without a Dental Specialties Center were more likely to use SIGAF.*

Key words *Prescription Drug Monitoring Programs, Anti-Bacterial Agents, Dental Care*

Resumo *O objetivo deste artigo é avaliar a associação entre fatores socioeconômicos, organização dos serviços de saúde e a utilização de um sistema de gestão e monitoramento da dispensação de antibióticos prescritos por cirurgiões-dentistas em Minas Gerais, Brasil. Estudo epidemiológico ecológico que analisou dados secundários do Sistema Integrado de Gestão da Assistência Farmacêutica (SIGAF) da Secretaria de Estado de Saúde de MG, Brasil, em 2017. Treze variáveis independentes foram analisadas para testar a influência destas com a adesão dos municípios ao SIGAF das prescrições odontológicas de antibióticos. Foram realizadas análises estatísticas descritivas, e a técnica de Árvore de Classificação e Regressão foi utilizada. Foram examinadas 57.279 prescrições de antibióticos prescritos por dentistas e registradas no SIGAF. Fatores socioeconômicos não foram associados ao uso do SIGAF para registro dessas prescrições. A cobertura de saúde bucal esteve positivamente associada à utilização do SIGAF para as dispensações de antibióticos prescritos por cirurgiões-dentistas. A presença de Centro De Especialidade Odontológica, esteve negativamente associado ao desfecho. Municípios com maior cobertura de saúde bucal e sem Centro de Especialidade Odontológica foram mais propensos a utilizar o SIGAF.*

Palavras-chave *Monitoramento de Medicamentos, Antibacterianos, Assis*

[1] Programa de Pós-Graduação em Odontologia, Faculdade de Odontologia, Universidade Federal de Minas Gerais (UFMG). Av. Antônio Carlos 6627, Pampulha. 31270-800 Belo Horizonte MG Brasil. junio.alex@hotmail.com
[2] Departamento de Farmácia Social, Faculdade de Farmácia, UFMG. Belo Horizonte MG Brasil.
[3] Faculdade de Educação, UFMG. Belo Horizonte MG Brasil.
[4] Departamento de Odontologia Comunitária e Preventiva, Faculdade de Odontologia, UFMG. Belo Horizonte MG Brasil.
[5] Bureau of Infectious Disease and Laboratory Sciences, Massachusetts Department of Public Health, Boston USA.

Introduction

In Brazil, dental care is provided, free of charge, through the Brazilian National Health System (BNHS), a public health system whose principles include universal access[1]. Among the advances achieved by the BNHS in recent years is the introduction of Healthcare Networks (HCN) as a model of care, in which the main objective is to overcome the high fragmentation of health actions and services and to qualify the management of care[2]. The components of the operational structure of the HCN comprehend support systems, which include pharmaceutical care and health information systems, which are intended to generate quality information and support the social construction of the HCN[3]. In the state of Minas Gerais (MG), the Oral HCN was introduced in 2013 and has since then been the care model proposed by the state administration to promote improvements in the oral health conditions of the population[4].

Pharmaceutical care is part of the process of healing, rehabilitation, and disease prevention, thus it is an integral part of BNHS[5,6]. In pharmaceutical care, drug dispensing must be organized to ensure access to users, taking into account the principles of the BNHS. Dispensing protocols must be reliable to ensure the quality of information, the management and control of information, and the tracking of patients to support the correct and consistent administration and rational use of medicines[7].

The data generated by information systems should be used for public health surveillance to support the planning, monitoring, and evaluation of health interventions and services[8]. The quality of these data is defined in terms of their integrity and validity, assuming that the complete data have no missing values, and that the valid data contain no errors caused by invalid codes or systematic deviations. The rates and quality of these data sets are closely related to the acceptability of individuals and organizations to participate in the public health surveillance system. Therefore, people must be prepared to report and record accurate, consistent, complete, and timely data[9]. Another element that influences the effective use of information systems is their level of usability, defined as the ease with which people interact with the tool[10].

In dental practices, antibiotics, along with analgesics, are the most commonly prescribed medications for the treatment of dental and oral conditions[11-14]. These drugs have revolutionized the control of infectious diseases, and their dental prescription for therapeutic and prophylactic purposes has increased[14,15], despite the well-documented association between antimicrobial resistance and antibiotic use.

Globally, there are several cases of epidemiological surveillance of the prescriptions of antibiotics[16]. These include the European Surveillance of Antimicrobial Consumption, which consists of an international network of surveillance systems launched in 2001 with the aim of collecting comparable and reliable data on antibiotic use in Europe to assess temporal trends in human exposure to these drugs[17,18]. In Brazil, there are still major organizational challenges in building a robust database to track pharmaceutical care at the national level[19]. In MG, a state in southeastern Brazil, the Pharmaceutical Assistance Management System (in Portuguese, *Sistema Integrado de Gerenciamento da Assistência Farmacêutica* - SIGAF) was developed to support and subsidize the implementation of activities and work processes developed in public pharmacies in each town, integrating them into a single network[20]. Little is known about the factors associated with the use of this information system by the municipal administration. Evaluations of oral health interventions in primary health care in Brazil show an association between their performance and socioeconomic and service organization factors[21,22]. Investigating the explanatory factors for the use of a registration system for the dispensing of antibiotics prescribed by dentists may help monitor the use of antibiotics in dental practices of public oral health services. The aim of this study was to investigate the association between socioeconomic factors, health care organizations, and the use of a management and monitoring system for the dispensing of antibiotics prescribed by dentists in public health services in MG, Brazil.

Methods

This is an ecological-epidemiological study conducted at the municipal level. Data were obtained from the SIGAF of the State Health Department of MG (SES-MG), after approval by the institution. Data refers to drug dispensing in public health services registered in the system in 2017. The study was approved by the Research Ethics Committee of Universidade Federal de Minas Gerais under the code CAAE-88465118.8.0000.5149.

The database was initially analyzed using Excel v. 2016 (Microsoft, Seattle, USA) and later

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using SPSS v. 25.0 (IBM SPSS Statistics for Windows, Armonk, USA). To select dispensing drugs prescribed by dentists, the names of all prescribers and their registration numbers in the Professional Council were matched with the official list of dentists from the Regional Council of Dentistry of MG (CRO-MG). Dispensing records whose data from prescribing dentists did not match those in the CRO-MG list, records without information on the prescribed quantity, records that did not include the name of the municipality of the health unit, and records of medical and hospital product dispensing were excluded from the study.

Data from each dispensing were classified according to the Anatomical Therapeutic Chemical (ATC) Classification System included in the 2019 ATC/DDD index[23]. The J01 drugs (systemic antibiotics), registered in the second level of the ATC classification (Therapeutic subgroup), were the core subject of this study. The number of dispensed drugs, and the number of units dispensed, as well as the number of people to whom they were dispensed, were calculated. The dispensing drugs were grouped by municipality. The outcome of this study was municipal adherence (Yes, No) to SIGAF considering dental prescriptions of antibiotics.

The following covariates were measured for each municipality: Municipality type (rural, mixed, or urban); Dental Specialties Center [DSC] (yes or no); Rural population rate; Gini Index; Human Development Index; Number of families served by the *Bolsa Família* Program (the national conditional cash transfer program directed to vulnerable families) per 1,000 inhabitants; Dentists who work at BNHS per 1,000 inhabitants; Oral Health Teams type I per 1,000 inhabitants; Oral Health Teams type II per 1,000 inhabitants; Percentage of population covered in oral health in the Family Health Strategy; Oral healthcare coverage; Coverage of first dental appointment; Percentage of preventive and restorative procedures. Descriptions of these covariates are provided in Chart 1. Numeric variables were dichotomized by median, except for coverage of first dental appointment, which was dichotomized as 100% or less than 100%.

Descriptive statistical analyses were performed for the entire state of MG as well as for health macro-regions. The Classification and Regression Tree (CART) technique was used to identify municipality variables that were associated with the record of antibiotic dispensing in dental care. CART is a decision tree built on a dependent variable and a set of covariates, in which groups are subdivided into subgroups and so on[24]. The constructed analytical model consisted of one dependent variable and thirteen covariates. The successive subdivisions of the total dataset were done with the Chi-Square Automatic Interaction Detection (CHAID) method. For each subdivision, the procedure selects the independent variable that has the strongest interaction with the dependent variable. It also grouped categories for each variable that were not significantly different from the dependent variable. The criteria used for CART were: first, each node – the label for each subset resulting from a subdivision rule – should have at least 50 observations before the next subdivision; second, each terminal node should have at least 30 observations; and third, the model would not consider subdivisions whose significance probability (p-value) is equal to or greater than 0.10.

Results

In 2017, out of 145,598 prescriptions written by dentists, 2,111 were excluded. In this study, the total of 57,279 antibiotic prescriptions were analyzed. The overall description of patients, dentists and antibiotics is presented in Table 1.

Of the 853 municipalities in MG, 49.35% (n=421) reported dispensing antibiotics prescribed by dentists. Amoxicillin dispensing was recorded by 97.62% (n=411) of the municipalities. Table 2 described the 13 covariates stratified by municipalities with and without SIGAF affiliation.

Among the 13 covariates, oral healthcare coverage was that which had the greatest impact on Node 0. This variable divided the municipalities into two groups: those with 100% coverage (Node 1) and those with less than 100% coverage (Node 2). Among the municipalities with 100% oral healthcare coverage (n=513), 52.2% used SIGAF. Among the municipalities with less oral healthcare coverage, 45.0% were using SIGAF. Successive subdivisions were made to identify another independent variable influencing both Node 1 and Node 2 subgroups. In the Node 1 group, no covariate influenced the model, while in Node 2, municipalities with a DSC affected the outcome, resulting in two additional subgroups – Node 3 and Node 4. The use of SIGAF was lower in municipalities with a DSC (Figure 1).

The macro-region with the highest percentage of municipalities that adhered to SIGAF was

Chart 1. Description of the analyzed independent variables. Minas Gerais, Brazil, 2017.

Independent variables	Definition	Year	Source
Municipality Type	Classification of rural and urban areas in municipalities	2017	IBGE
Dental Specialties Center	Municipality that has one or more health establishments with specialized outpatient dental service accredited by the Ministry of Health as a secondary care unit in the Oral Healthcare Network	2017	Ministry of Health
Rural population rate	Measures the percent of rural population in relation to the total population of the municipality. Formula: (Total rural population)/(total population of the municipality)	2010	DATASUS
Gini Index	Measure of income inequality in a society. Ranges from 0 to 1, with 1 corresponding to maximum inequality	2010	DATASUS
Human development Index	Measure composed of three indicators of a population: longevity, education, and income. Ranges from 0 to 1, with higher values indicating greater human development	2010	Atlas of Human Development
Number of families served by the *Bolsa Família* Program per 1,000 inhabitants	Measures the rate of families assisted by the income transfer program, *Bolsa Família*, in relation to the total population. Formula:(Number of families under the *Bolsa Família* Program x 1,000 inhabitants)/(total population of the municipality)	2017	Ministry of Cities
Dentists who work at BNHS per 1,000 inhabitants	Measures the rate of dentists working in the BNHS per 1,000 inhabitants. Formula: (Number of dentists in the BNHS x 1,000 inhabitants)/(total population of the municipality)	2017	DATASUS
Oral Health Teams type I per 1,000 inhabitants	Measures the rate of teams composed of one dentist and one oral health assistant or technician who work in the Family Health Strategy per 1,000 inhabitants. Formula: (Number of teams modality I x 1000 inhabitants)/(total population of the municipality)	2017	DATASUS
Oral Health Teams type II per 1,000 inhabitants	Measures the rate of teams composed of one dentist, one oral health technician, and one oral health assistant or technician who work in the Family Health Strategy per 1,000 inhabitants. Formula: (Number of teams modality II x 1000 inhabitants)/(total population of the municipality)	2017	DATASUS
Percentage of population covered in oral health in the Family Health Strategy	Measures the population's access to oral health services that have oral health teams in the Family Health Strategy. It is estimated that each oral health team must cover 3,450 inhabitants. Formula: Number of oral health teams in the Family Health Strategy x 3,450 x 100)/(total population of the municipality)	2017	e-Gestor
Oral healthcare coverage	Percentage of the population with access to oral health services considering the oral health teams in the Family Health Strategy and teams allocated to other primary health care. Formula: $\frac{\left[\begin{array}{c}(\text{Number of oral health teams in the Family Health Strategy x 3.450}) + \\ (\text{Number of other oral health teams in primary health care x 3.000})\end{array}\right] \text{x } 100}{\text{total population of the municipality}}$	2017	e-Gestor
Coverage of first dental appointment	Percentage of the population that received, in the last 12 months, an assessment of general health conditions and oral clinical examination for the purpose of diagnosis and development of a preventive-therapeutic treatment plan. Formula: (Number of first dental appointments x 100)/(total population of the municipality)	2017	DATASUS
Percentage of preventive and restorative procedures	Percentage of preventive and restorative dental procedures in relation to the total number of dental procedures performed. Formula: (Number of individual preventive and restorative dental procedures x 100)/(Total number of individual preventive, restorative, and surgical dental procedures)	2017	DATASUS

Notes: DATASUS=Department of Informatics of the Brazilian National Health System; e-Gestor=Primary Care Information and Management Platform; IBGE=Brazilian Institute of Geography and Statistics.

Source: Authors.

the West (70.91%) and that with the lowest percentage was the South (28.10%). Macro-regions with a larger number of municipalities had a lower percentage of SIGAF adherence. Table 3 shows the composition of health macro-regions, and the number and percentage of municipalities that adhered to SIGAF.

Table 1. Description of patients, dentists and prescribed antibiotics in Minas Gerais, Brazil, 2017.

Quantitative variable	mean	SD
Number of dentists per municipality that used SIGAF for antibiotic prescriptions (n=2,294)	7.38	8.95
Categorical variables	**N**	**%**
Patients (n=40,630)		
Male	17,081	42.04
Female	23,549	57.96
Dentists (n=2,294)		
Male	1,074	46.82
Female	1,220	53.18
Prescribed antibiotics (n=57,279)		
Amoxicillin	48,381	84.47
Azithromycin	5,091	8.89
Amoxicillin + Potassium Clavulanate	1,739	3.04
Cefalexin	1,285	2.24
Others	783	1.37

Source: Authors.

Discussion

This study examined the associated factors with municipal usage of antibiotic prescription management and monitoring system. Municipalities with high oral healthcare coverage showed higher adherence to SIGAF. In addition, towns without DSC were more likely to use SIGAF.

The descriptive analysis showed that by 2017 amoxicillin was the uppermost prescribed antibiotic in MG. Several surveys worldwide have reported that amoxicillin was the most commonly prescribed antibiotic by dentists[25,26]. One possible explanation for this could be the convenience of the eight-hour interval between doses, regardless of meals[26]. Moreover, the high prescription of amoxicillin could also be due to its availability in the pharmacies of health units at the time of demand, considering that this drug is part of the Brazilian National List of Essential Medicines[27]. Most patients were female, confirming the findings of studies on gender differences in health in

Table 2. Municipal covariates stratified by registration or not of antibiotics prescribed by dentists in the Pharmaceutical Care Management System (SIGAF) in Minas Gerais, Brazil, 2017.

Covariates		n (%)		Mean; median	
		G1 counties	G2 counties	G1 counties	G2 counties
Municipality type	Urban	94 (22.33)	107 (24.77)		
	Mixed	51 (12.11)	54 (12.50)		
	Rural	276 (65.56)	271 (62.73)		
Dental Specialties Center (Yes)		36 (8.55)	52 (12.04)		
Rural population rate				0.32; 0.30	0.32; 0.29
Gini Index				0.48; 0.48	0.48; 0.48
Human Development Index				0.66; 0.67	0.67; 0.67
Number of families served by the *Bolsa Família* Program per 1.000 inhabitants				77.80; 69.82	78.18; 71.75
Dentists who work at BNHS per 1.000 inhabitants				0.60; 0.51	0.60; 0.51
Oral Health Teams type I per 1.000 inhabitants				0.19; 0.18	0.22; 0.21
Oral Health Teams type II per 1.000 inhabitants				0.08; 0.00	0.04; 0.00
Percentage of population covered in oral health in the Family Health Strategy				77.00; 99.00	72.00; 93.00
Oral healthcare coverage				87.00; 100	83.00; 100
Coverage of first dental appointment				11.00; 8.00	10.00; 8.00
Percentage of preventive and restorative procedures				90.00; 91.00	89.00; 91.00

Notes: G1=municipalities using the SIGAF to record the dispensing of antibiotics prescribed by dentists; G2=municipalities not using the SIGAF.

Source: Authors, based on public data published by: IBGE, Ministry of Health, DATASUS, Atlas of Human Development, and Ministry of Cities.

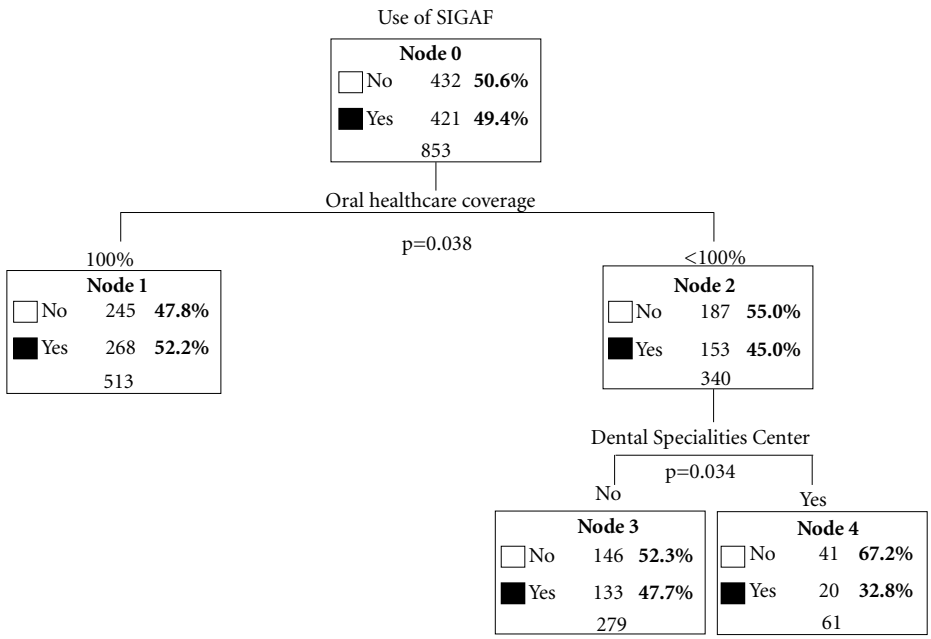

Figure 1. Factors associated with the use of the Pharmaceutical Care Management System (SIGAF) for registration of antibiotics prescribed by dentists in Minas Gerais, Brazil, 2017.

Source: Authors.

Table 3. Health macro-regions, total counties, population, number and percentage of counties using the SIGAF. Minas Gerais, Brazil, 2017.

Health macro-region	Number of counties	N - % of counties using SIGAF		2016 population
Center	103	41	39.81	820,865
Center South	50	33	66.00	377,858
Jequitinhonha	23	16	69.57	196,162
East	86	49	56.98	702,854
Southeast	53	32	60.38	377,687
Northeast	63	32	50.79	451,539
Northwest	33	23	69.70	466,663
North	86	37	43.02	1,007,808
West	55	39	70.91	789,833
Southeast	94	47	50.00	656,460
South	153	43	28.10	701,738
North Triangle	27	18	66.67	312,623
South Triangle	27	11	40.74	123,233
Total	853	421	49.35	6,985,323

Source: Authors, based on public data published by: IBGE, DATASUS, Official Plan for Regionalization of Minas Gerais, 2017.

industrialized societies. Despite having a higher life expectancy than men, women report more illnesses and mental health problems and use more health services than men do[28]. According to DataSUS, in June 2017, 23,094 dentists were working in MG, and the minority worked to the BNHS (n=9,908; 42.90%)[29], however, SIGAF recorded antibiotic prescriptions made only by 2,294 prescribers. There are some feasible explanations to that; first, since compliance with SIGAF is not compulsory less than half of the towns used this system. Also, for some reasons, such as lack of availability of the prescribed drug or the distance from the patient's house to the public pharmacy[30], it is possible that after receiving a prescription some patients would rather purchase the medicines in a private drugstore, which might have directly impacted the overall number of prescribers in SIGAF records. The female predominance among prescribers is consistent with the literature, showing that Brazilian dentists are predominantly women in 92.59% of Brazilian states[31]. The process of feminization of the dental workforce has been reported by several authors and is also observed in the United States and Europe[32].

Primary care epidemiology applies epidemiological principles and methods to the study of health problems in primary care in order to overcome these problems[33]. In this sense, using adequate statistical models is important to identify the factors that are really associated with a given outcome. To our analysis, we used the CART, which advantage is the comprehensibility of the results since it allows us to understand the classification structure and all the subsequent subdivisions[24]. Another advantage of using CART in public health studies is that identifying high-risk population subgroups could be helpful to target interventions, and consequently reduce health disparities[34,35]. Previous international studies on antibiotic prescribing by dentists[15,25,26] did not address the use of information systems for monitoring prescriptions. The majority of the municipalities studied here did not use the SIGAF. Therefore, progress is needed in monitoring antibiotic prescribing in the BNHS, especially in the dental sector. Global experience shows that a surveillance system for antibiotic prescriptions is extremely important to identify the pattern of their use and to enable the monitoring and control of the global phenomenon of antibiotic resistance[16].

Municipalities are free to decide whether or not to join the SIGAF. This decision may be related to the understanding of managers and health workers, as well as the importance given to these records in monitoring antibiotic prescribing[36]. The literature supports this hypothesis, as acceptability, usefulness, and accessibility are important attributes of a health surveillance system[9]. Registration in the SIGAF system is not compulsory nor does it have a direct influence in the transfer of funds to municipalities, which would discourage participation. It is also possible that towns could use a local information system[20].

Several studies have shown the importance of human resources in the healthcare work process and outcomes, especially in oral health, but little is known about the impact on antibiotic surveillance systems[37]. In the present study, municipalities with a greater proportion of oral health teams showed higher adherence to SIGAF system. This may indicate that these municipalities organize their health services better so as to achieve full oral healthcare coverage of the population. Since the smallest municipalities had the best oral healthcare coverage, it can be concluded that a smaller number of teams can collaborate better in managing municipal work processes. As a result, these municipalities presented a higher rate of SIGAF use. Oral health care in municipalities with large populations is still a challenge in Brazil. It is well-known that health systems organized through primary care are more effective and efficient, and that human resources in health are essential to strengthen services and ensure better access to health. Recent studies suggest that the work process and structure of services are related to the performance of public oral health services in Brazil[38,39]. From this study, it can be inferred that the municipalities with 100% oral healthcare coverage have more well-organized services and work processes and include the use of the SIGAF in their routines. It could be that these municipalities, due to their small population, require a small number of oral health teams to achieve 100% coverage. Hence, the generation of health surveillance information took on a small scale and could allow for broader and more effective management.

The highest frequency of use of SIGAF in municipalities without DSC is an interesting finding. DSC provide specialized secondary oral healthcare services and, they are generally placed in big and populous regions[40]. Thus, it may be more problematic to large municipalities to organize their information systems. More research is necessary to fully understand the relationship between DSC and the record of prescribed medicines in SIGAF.

Socioeconomic factors affect the organization of oral health services[38]. However, in our study, these factors showed no association with the municipalities' use of the SIGAF. As SIGAF use is still a novelty in local health management, further evaluation studies are needed to investigate the influence of socioeconomic variables on it.

This study has some limitations that should be addressed. First, the data analyzed in this research is from 2017, then it may not reflect the current situation. Second, as data collected only concern the antibiotics prescribed, dispensed, and registered in the SIGAF system, it is not possible to assess antibiotic prescribing in communities that have not registered their prescriptions in this system. Ecological studies are limited by the fact that conclusions drawn at the aggregate level cannot be extrapolated to the individual level. Similarly, despite all methodological precautions, the analysis was based on secondary data collected for purposes other than those of the present study. Finally, the evaluation of physicians' prescriptions in the SIGAF system was not performed. Despite the drawbacks, it is worth noticing that the result of this research provided

some insights about the factors that might be related to the usability of SIGAF in MG.

In conclusion, municipalities with high oral healthcare coverage and those without DSC were more likely to use SIGAF for the dispensing of antibiotics prescribed by dentists in public health services in MG.

Collaborations

JS Santos, EA Pereira Júnior and MHNG Abreu conceived the original idea, collected and analyzed data, interpreted the results and wrote the manuscript. EA Pereira Júnior performed statistical analysis by CART. AJS Cruz, EA Pereira Júnior, CM Ruas, FF Mattos and M Klevens interpreted the results and revised the manuscript. All authors reviewed and approved the final draft.

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