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Caries-related hospital morbidity in the Brazilian Unified Health System from 2008 to 2022

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Abstract: Dental caries is an important Public Health issue. However, the treatment of this disease in tertiary dental care requires further investigation. Therefore, the objective of this study was to evaluate caries-related hospital morbidity in the Brazilian Unified Health System (SUS) from 2008 to 2022. An ecological study was conducted with secondary data on caries-related Hospital Admission Authorizations (AIH) and in-hospital dental procedures (IDP). Data were collected nationwide and statistical analysis was performed with a significance level (p) of 5%. In the last 15 years, 3,474 caries-related AIH and 63,657 IDP were approved within SUS. There was a significant upward trend in the number of caries-related AIH (p = 0.018) and a stationary trend in the number of caries-related IDP (p = 0.841). Moreover, from 2008 to 2022, R$ 1,160,843.09 was allocated for caries-related AIH. Hospital mortality was 0.29% (10 deaths), and 75.1% were elective inpatient admissions. Among SUS users, adults constituted the majority (49%), with a higher frequency of males (59.8%) and whites (46.2%). The most frequent type of caries-related IDP was restoration of permanent teeth (55.3%). Nonetheless, during the COVID-19 pandemic years, significant reductions in caries-related AIH and IDP within the SUS were observed (all p <0.05). Thus, within the SUS, caries-related tertiary dental care has shown a specific pattern over the last 15 years, including an increase in hospitalizations and a high number of in-hospital dental procedures, especially before the COVID-19 pandemic onset.

Keywords: Dentistry; Dental Caries; Delivery of Health Care; Morbidity; Hospitalization.

Introduction

Dental caries (DC) is considered a relevant Public Health issue. Nowadays, it is evident that different population profiles and unequal access to oral health services continue to cause disparities in DC prevention and treatment.[1,2] From this perspective, it is understood that access to timely DC treatment should consider the implementation of public policies and the structuring of health systems.[3] In fact, the availability of public oral health services can influence the caries experience, highlighting the importance of Public Health settings in addressing this disease.[4]

DC treatment and oral health services are primarily provided on an outpatient level. However, there are instances when dentists recommend hospitalization to access resources unavailable in outpatient dental services,[5,6] such as general anesthesia and medical support for previous comorbidities. This healthcare modality is often chosen when dealing with medically compromised or uncooperative patients at an outpatient level, both for elective and urgent dental treatments. Although feasible, the associated costs and technologies can limit access.[7,8] Furthermore, it has already been demonstrated that the organization of oral health services is an important factor in the use of these resources and technologies for patients with complex disabilities requiring dental treatments.[9]

Apart from systemic health problems, caries-related hospital admissions may reflect Public Health problems, such as negligence, socioeconomic disparities in access to oral health services, and the need for advanced treatments for oral diseases that can be managed and prevented by the Primary Health Care setting (outpatient level). However, some patients may require hospital admission due to non-avoidable factors.[10,11] In addition, there is evidence indicating an increased use of hospital emergency rooms to address dental-related issues, as well as in the number of hospital admissions for non-traumatic dental conditions (*e.g.* dental caries) in different countries and health systems.[12-15] The intersection between DC as a Public Health issue and its treatment in inpatient settings raises the question: how does the Brazilian Unified Health System (SUS) fit into this scenario?

SUS is one of the largest health systems in the world, and the majority of Brazilians rely on it for healthcare.[16] However, concerning Oral Health, dentists primarily work at the outpatient level within SUS, particularly in Primary Health Care (Family Health Strategy; PHC/FHS).[17] Nonetheless, there is a need to continue improving oral health care in SUS, especially in terms of providing comprehensive care and increasing access of vulnerable populations to oral health services at all levels.[17,18] Additionally, it is known that SUS users may experience difficulties in accessing emergency dental care within healthcare networks[19] and untreated DC remains a relevant problem in the country.[20]

Therefore, another reasonable issue is the extent of caries-related hospital morbidity experienced within SUS: is there a high number of caries-related hospital admissions and in-hospital dental procedures (IDP)? Currently, there is a lack of investigation addressing this question. Although solving the most prevalent oral health problems in the population is a PHC goal, in addition to the efforts guided by the National Oral Health Policy ("Brasil Sorridente"), there is a need to investigate the availability of oral health services and its correlation with DC, which is critical for a country with a continental dimension like Brazil.[4,16,17] In the outpatient setting (primary and secondary level), a high number of caries-related dental procedures, such as restorations and fluoride applications, have been performed in recent years within SUS.[21] However, there is no analysis of caries-related dental care at the tertiary level in this health system.

Moreover, the COVID-19 pandemic onset negatively impacted the productivity of oral health services within SUS. Although the impact on outpatient dental procedures (including caries-related ones) has been widely measured,[22,23] it was not possible to find evidence of caries-related in-hospital assistance (tertiary-level dental care).

Therefore, the objective of this study was to evaluate caries-related hospital morbidity within SUS from 2008 to 2022. In addition to the descriptive morbidity-related outcomes, three alternative hypotheses were explored: (H_1) there was a significant increasing temporal trend in the number of caries-related AIH within SUS from 2008 to 2022, (H_2) there was a significant increasing temporal trend in the number of caries-related IDP within SUS from 2008 to 2022, and (H_3) the COVID-19 pandemic has reduced the number of caries-related AIH and IDP within SUS.

Methodology

Study design

An epidemiological study was carried out, with an ecological, longitudinal, retrospective and quantitative

approach.[24] The study evaluated data for Brazil, encompassing all regions and the Federal District. The time frame selected for the analysis was the period from 2008 to 2022 (last 15 years; n = 15), considering annual data. To assess the impact of the COVID-19 pandemic, four periods were defined: pre-pandemic (from April 2019 to March 2020), first year (from April 2020 to March 2021), second year (from April 2021 until March 2022), and third year (April 2022 until March 2023), considering monthly data (n = 12 in each period). To enhance the study report, the Portuguese version of the STROBE initiative checklist (Strengthening the Reporting of Observational Studies in Epidemiology) was used.[25]

Ethical aspects

Data were collected from national open access databases, as public domain. Considering the ecological approach, there was no direct interaction with human subjects. Furthermore, there was no data for the identification of SUS users. Therefore, in accordance with national resolution 510 of April 7, 2016, published by the National Health Council - Ministry of Health,[26] ethical approval by a Research Ethics Committee was not required.

Data source

Data used in the study were collected from SUS and made available by the Department of Informatics (DATASUS). In terms of assessing caries-related hospital morbidity within SUS and its funded services, data available from the National Hospital Information System (SIH/SUS) were used.[27] It is a system for managing and consolidating SUS-related data. SIH/SUS data are based on Hospital Admission Authorizations (AIH), which considers the diagnosis that led to hospital admission, as well as financial and sociodemographic data. Additionally, data from approved caries-related IDP were used, also from SIH/SUS. Indeed, the SIH/SUS is considered a valuable tool for epidemiological monitoring of health conditions and diseases in Brazil.[28]

Variables

The primary outcome variable was the number of caries-related AIH in SUS from 2008 to 2022, considering its raw and normalized values per 1,000,000 residents in each year (correcting for the population factor due to possible demographic changes over time). The circumstance (elective or urgent), regime (public or private), number of deaths, and hospital mortality rate (HMR) were also retrieved. HMR was obtained from the ratio between the number of deaths and AIH in each year. The projection of residents in Brazil between 2008 and 2022 from the Brazilian Institute of Geography and Statistics (IBGE) was used as a proxy measure.[29] Secondary variables included sociodemographic (sex, color/race, age, city, state, and region in which AIH were approved) and financial (absolute costs) data.

In addition, the number of caries-related IDP carried out in the SUS was collected as a secondary variable. It is important to clarify that these procedures may result from caries-related AIH or be secondary to other oral diseases, and it is not possible to differentiate them. Restorative procedures were divided into: restorations in primary teeth (SIH/SUS codes: #0307010023 "*restorations in primary teeth*"; #0307010112 "*restoration in anterior primary teeth with composite resin*"; #0307010082 "*restoration in posterior primary teeth with composite resin*"; #0307010104 "*restoration in posterior primary teeth with glass ionomer cement*"; #0307010090 "*restoration in posterior primary teeth with amalgam*"), restorations in permanent teeth (SIA/SUS codes: #0307010031 "*restoration in anterior permanent teeth with composite resin*"; #0307010040 "*restoration in posterior permanent teeth*"; #0307010120 "*restoration in posterior permanent teeth with composite resin*"; #0307010139 "*restoration in posterior permanent teeth with amalgam*"), and other caries-related interventions (SIH/SUS codes: #0307010074 "*atraumatic restorative treatment*"; #0101020090 "*temporary sealing of dental cavity*"; #0101020058 "*cariostatic application - per tooth*"; #0101020066 "*sealant application - per tooth*"; #0101020074 "*topical fluoride application - individual per session*"). The number of procedures was also normalized by the population factor, as mentioned above.

Data collection

Data collection was based on the considerations of Bittencourt *et al*. (2006)[28] regarding the applicability of SIH/SUS in epidemiological studies in public

health, as well as on the procedure carried out by a similar study.[30] The data was collected by a single researcher in April 2023. Caries-related AIH were screened using the filters available in SIH/SUS to stratify according to the list of morbidities of the International Statistical Classification of Diseases and Related Health Problems - 10th revision, (ICD-10), reviewed by the World Health Organization. DC is included in Chapter XI, which deals with diseases of the digestive system (K00-K93 codes), identified by K02.[31]

Data analysis

Statistical analysis was carried out using the JAMOVI (version 2.3.15, Sydney, Australia) and PAST (version 4.03, Oslo, Norway) softwares. The significance level (p) was set at 5% ($\alpha = 0.05$). The data were presented using descriptive measures of frequency (absolute and relative), central tendency (mean), and dispersion (standard deviation, minimum, and maximum). To assess the temporal tendency of caries-related AIH, the hypothesis of first-order serial autocorrelation was examined by Durbin-Watson statistic (DW), which was rejected in the normalized values (1,000,000 residents; DW: 1.914, p = 0.432). The same outcome was observed for the number of caries-related IDP in normalized values (DW: 1.512, p = 0.171). Furthermore, the hypothesis of normality of the residuals was examined and confirmed by the Shapiro-Wilk statistic (W) in both datasets (W: 0.942 and 0.920, p = 0.409 and 0.252, respectively).[32-34]

Hence, the slope value (β_1; angular coefficient) was estimated by linear regression using the Ordinary Least Squares (OLS) method after the logarithmic transformation (log10) of the dependent variable. The Annual Percent Change (APC) was estimated by the expression = $[-1+10^{(\beta 1)}] * 100\%$. The 95% confidence interval ($CI_{95\%}$) for the APC was estimated using the minimum and maximum β_1-values after OLS approach, using the expression = [$\beta_1 \pm$ (*t*-critical value*β_1-standard error)]. The trend over time was determined as stationary ($p \geq 0.05$), increasing ($p < 0.05$ and positive angular coefficient), or decreasing ($p < 0.05$ and negative angular coefficient).[33,34] Moreover, Generalized Linear Models (GLM) were used to compare the incidence ratios of caries-related AIH and IDP. Considering Quasi-Poisson distributions (QPO), a robust variance correction was carried out, and incidence rate ratios (IRR) were compared by maximum likelihood estimation in the logarithmic link-function (Log-likelihood ratio).[22,32]

Results

From 2008 to 2022, 3,474 caries-related AIH and 63,657 caries-related IDP were approved within SUS. Table 1 presents the descriptive measures and analysis of the temporal trend, and Figure presents this panorama over the last 15 years. It is noteworthy that there was no data available for caries-related IDP in 2008 and 2009. In 2019, both variables reached their highest numbers but experienced an expressive decrease in 2020. However, when considering caries-related AIH, the linear trend lines indicate a significant slope angle from the beginning to the end of the time series. This pattern was not observed in caries-related IDP. Moreover, disregarding the COVID-19 pandemic years (2020, 2021, and 2022), the temporal trend of caries-related AIH continued to increase significantly (p = 0.043), and caries-related IDP increased significantly (p = 0.032, APC = 8.14% [CI95% = 0.69, 16.1%], $R^2 = 0.429$).

Examining sex differences, the projected resident population suggested a relative proportionality (M:F) in all years (data not shown). However, 2,079 (59.8%) caries-related AIH were in males and only 1,395 (40.2%) in females, but there was no statistically significant difference in incidence ratio (female *versus* male, p = 0.102, IRR = 0.650, $CI_{95\%}$ = 0.390, 1.065).

Moreover, from 2008 to 2022, R$ 1,160,843.09 was allocated for caries-related AIH. Of these, 10 deaths were reported, accounting for a HMR of 0.29%. When stratified between elective and urgent, all deaths reported were urgent cases (HMR: 1.15%; six male and four female users). Table 2 presents the absolute and relative frequency of the other caries-related AIH features. It is noteworthy that color/race and regime, as non-mandatory data, showed a high frequency of missing data (not reported or

Table 1. Caries-related Hospital Admission Authorizations and in-hospital dental procedures approved in the Brazilian Unified Health System from 2008 to 2022.

Variable	Hospital Admission Authorizations			In-hospital dental procedures
	Normalized (1,000,000 residents)	Male	Female	Normalized (1,000,000 residents)[+]
Average (annual)	1.12	1.36	0.89	23.8
Standard deviation	± 0.76	± 0.90	± 0.62	±8.98
M:F	N/A	1.49 [1.31, 2.67]		N/A
Minimum	0.16	0.22	0.10	9.1
Year	2014	2014	2014	2010
Maximum	2.58	3.07	2.10	34.8
Year	2019	2019	2019	2019
β_1	0.050	0.050	0.051	N/A
($CI_{95\%}$)	(0.021, 0.069)	(0.023, 0.070)	(0.018, 0.072)	
R^2	0.365	0.381	0.338	N/A
p	0.018*	0.015*	0.021*	0.841
APC (%)	12.2	12.2	12.5	N/A
($CI_{95\%}$)	(5.00, 17.2)	(5.40, 17.5)	(4.20, 19.7)	
Trend	Increasing	Increasing	Increasing	Stationary

β_1: angular coefficient. R^2: coefficient of determination. $CI_{95\%}$: 95% confidence interval. APC: Annual Percent Change (%). *p <0.05. N/A: not applicable. []: minimum, maximum. ✣: from 2010 to 2022. Source: National Hospital Information System - Brazilian Unified Health System.

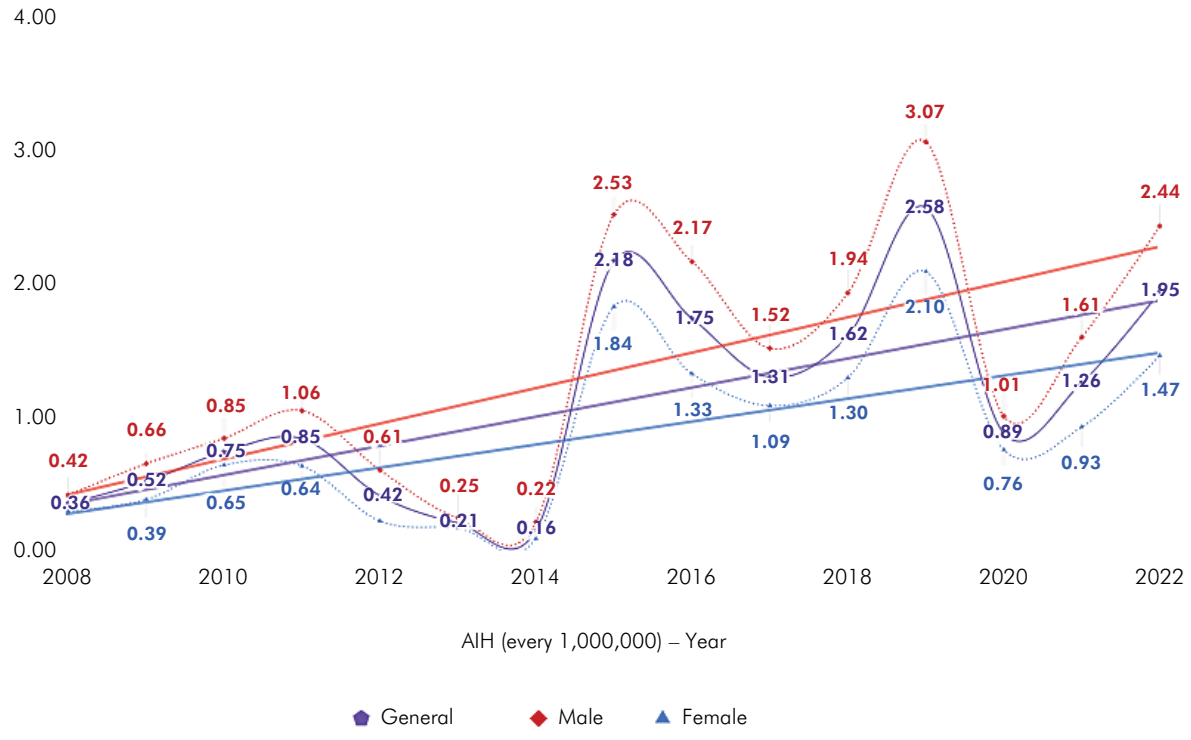

Figure. Caries-related Hospital Admissions Authorization (AIH) approved within the Brazilian Unified Health System from 2008 to 2022 (every 1,000,000 residents) (Brazil, 2023).

Table 2. Secondary features of caries-related Hospital Admission Authorizations approved in the Brazilian Unified Health System from 2008 to 2022 (Brazil, 2023).

Variable	Hospital admission authorizations	
	f	%
Region (hospitalization)		
North	41[L]	1.2[L]
Northeast	224	6.4
Southeast	2,951[H]	84.9[H]
South	90	2.6
Midwest	168	4.8
Region (residency)		
North	45[L]	1.3[L]
Northeast	231	6.6
Southeast	2,936[H]	84.5[H]
South	91	2.6
Midwest	171	4.9
Age (years)		
0–9	728	21.0
10–19	796	22.9
20–34	1,131[H]	32.6[H]
35–54	568	16.4
55–69	173	5.0
≥ 70	78[L]	2.2[L]
Color/Race		
White	1,605[H]	46.2[H]
Black	93	2.7
Mixed/Brown	828	23.8
Yellow	39	1.1
Indigenous	3[L]	0.1[L]
Not reported or ignored	906	26.1
Circumstance		
Elective	2,608[H]	75.1[H]
Urgent	866	24.9
Regime		
Public	865	24.9
Private (SUS-funded)	150[L]	4.3[L]
Not reported or ignored	2,459[H]	70.8[H]

f: absolute frequency. %: relative frequency. [H/L]: highest/lowest absolute or relative frequency. Source: National Hospital Information System - Brazilian Unified Health System.

ignored). In addition, by comparing the region of Brazil where hospital admissions occurred with the region where SUS users resided, similar frequencies were observed, indicating that the majority of users were hospitalized in the region where they lived.

Among Brazilian states, the majority of caries-related AIH were approved in São Paulo (2,236; 64.4%). Additionally, 1,623 (46.7%) were approved in Brazilian state capitals (often in São Paulo city, 1,273, 78.4%), while a small number was approved in municipalities with extreme poverty (26; 0.74%). At last, it is important to highlight that the number of caries-related AIH was lower than other hospitalizations related to oral health issues in Brazil over the last 15 years, such as "other disorders of the teeth and supporting structures" (87,905 AIH; K00-K01, K03-K08 codes) and "other diseases of the oral cavity, salivary glands, and maxillary bones" (156,550 AIH; K09-K14). Table 3 presents the frequency of caries-related IDP by group, with the predominance of restorations in permanent teeth.

Furthermore, Table 4 presents the incidence rate of caries-related AIH and IDP in pre-pandemic years and during the pandemic. The incidence of caries-related AIH was 73.7% lower in the first pandemic year and 47.8% lower in the second pandemic year, with no statistically significant difference in the third pandemic year. Moreover, the incidence of caries-related IDP was 79.5% lower in the first pandemic year, 63,2% lower in the second pandemic year, and 34% lower in the third pandemic year.

Table 3. Frequency of in-hospital caries-related dental procedures approved in the Brazilian Unified Health System from 2010 to 2022 (Brazil, 2023).

Variable	In-hospital caries-related dental procedures	
	f	%
Restorations in primary teeth	9,297[L]	14.6[L]
Restorations in permanent teeth	35,183[H]	55.3[H]
Others	19,177	30.1

f: absolute frequency. %: relative frequency. [H/L]: highest/lowest absolute or relative frequency. Source: National Hospital Information System - Brazilian Unified Health System.

Table 4. Incidence rate of caries-related Hospital Admission Authorizations and in-hospital caries-related dental procedures approved in the Brazilian Unified Health System in the COVID-19 pre-pandemic years and in pandemic years (Brazil, 2023).

Comparison	Distribution	IRR	95% confidence interval		p-value
			Lower	Upper	
Reference (pre-pandemic year)		Caries-related AIH			
Intercept	QPO	0.123	0.109	0.139	< 0.001*
First year		0.263	0.177	0.380	< 0.001*
Second year		0.522	0.386	0.700	< 0.001*
Third year		0.876	0.678	1.131	0.317
Reference (pre-pandemic year)		In-hospital caries-related dental procedures			
Intercept	QPO	1.352	1.240	1.469	< 0.001*
First year		0.205	0.157	0.264	< 0.001*
Second year		0.368	0.298	0.450	< 0.001*
Third year		0.660	0.556	0.781	< 0.001*

IRR: incidence rate ratio. P: Quasi-Poisson distribution. *p-value <0.05.

Discussion

In summary, the data available show that the number of caries-related AIH in the last 15 years was small in relation to other oral diseases of SUS users. The majority of SUS users who were hospitalized received elective care for DC, which are non-urgent hospital admissions. There was a predominance of adults, males, whites, and residents of the Southeast region of Brazil. Considering the region of hospitalization, there was also a predominance of health services in the Southeast region and in state capitals, especially in the city of São Paulo. Lastly, the majority of caries-related IDP were restorations in permanent teeth, which is in line with the predominant features in relation to SUS users.

Therefore, the first alternative hypothesis (H_1) was accepted, indicating a significant increasing temporal trend in the number of caries-related AIH in the SUS from 2008 to 2022. However, the second (H_2) was partially accepted, as there was no significant increasing temporal trend in the number of caries-related IDP in the SUS from 2010 to 2022, which was only observed when the COVID-19 pandemic years were removed from the calculation (from 2010 to 2019). At last, the third hypothesis (H_3) was accepted, since the number of caries-related AIH and IDP within SUS was lower during the COVID-19 pandemic years, especially in the first and second years.

In the initial analysis, the primary outcome can be interpreted in two ways: the increase in the number of caries-related AIH may reflect the increasing access to this service of SUS users (positive) or barriers to accessing outpatient oral health services prior to tertiary care (negative). The number of elective hospital admissions was an important variable, as these admissions were the majority in the last 15 years (more than 3/4 of caries-related AIH in the SUS), strengthening the positive perception of the outcome.

However, caries-related AIH occurred in a restricted panorama, concentrated in a single region of Brazil (Southeast), and more than 1/3 in a single city (São Paulo). This may represent inequalities in tertiary oral health care access in Brazil, which would be a negative outcome. As discussed by Mello *et al.* (2014)[35], oral health care by SUS focuses on primary and secondary care (Dental Specialty Centers). Tertiary dental care is often limited to some specialties, such as traumatology and stomatology.

Furthermore, the caries-related hospital admissions evaluated here were restricted to the K02 code (ICD) in the AIH, and other oral diseases that arise from an untreated caries lesion (*e.g.* pulpal/periapical diseases and odontogenic infections)[36] were not accounted for in hospital morbidity described here. In fact, DATASUS only distinguishes DC from other diseases that affect teeth and tooth-supporting tissues.[27] This might explain the high number of caries-related IDP

compared to the number of caries-related AIH: other oral diseases required restorative procedures as part of the treatment. In addition, although DC was the reason for hospital admissions, adverse events and systemic complications during the procedures, as well as iatrogenesis that may result in death,[37] were not presented by DATASUS, leading to a bias when attributing deaths and hospital mortality rates to caries-related AIH, as it is not possible to identify the death event.

Considering the predominance of elective caries-related AIH in the SUS, it is known that a significant number of IDP are performed on patients with special needs that require general anesthesia (which is often offered in public health services).[38] However, there is no information about the clinical features of SUS users, limiting the understanding of this outcome, although the high prevalence of DC in patients with special needs is a reality,[39] which would justify the high number of elective in-hospital care observed in the SUS over the last 15 years.

Furthermore, the COVID-19 pandemic onset was an immediate challenge to oral health services around the world, including within the SUS. Chisini *et al*. (2021)[22] demonstrated a reduction of outpatient restorative dental procedures (primary and secondary care) in 2020 compared to 2019 (March - August). In addition, they demonstrated an average of approximately 31,300 monthly restorative dental procedures per 100,000 inhabitants between March and August 2019, which reduced to approximately 947 in 2020. These numbers corroborate the perspective that DC care is predominantly done in an outpatient setting within SUS. However, with the COVID-19 outbreak, all levels of care were impacted, including the tertiary care, also considering caries-related dental assistance. Moreover, the impact on restorative dental procedures within SUS is linked to the decline of oral health actions and assistance, which mainly affect Brazilians who depend on the public health sector,[22,23] although the extension at the tertiary level has not been delimited for all types of dental procedures.

As limitations, it is important to acknowledge the ecological study approach (without adjustments). In addition, there is no information about which professional requested in-hospital dental care for DC, as well as which professional carried out caries-related IDP (non-compulsory data). The absence of data for caries-related IDP procedures in 2008 and 2009 can be justified by their inclusion in 2010[40]. Future investigations should continue to monitor these variables over time and evaluate other features in clinical charts that are not available from SIH/SUS.

Conclusion

Over the past 15 years, SUS has experienced a pattern in caries-related hospital morbidity, including an increase in the number of hospital admissions and in-hospital dental procedures (particularly before the COVID-19 pandemic), as well as discrepancies between different sociodemographic components. Moreover, there was a reduction in the caries-related tertiary dental care after the COVID-19 pandemic onset.

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