

## Human Development and Dental Caries in 12-Year-Old Brazilian Schoolchildren

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### ABSTRACT

**Objective:** To investigate the correlation between human development and dental caries in 12-year-old schoolchildren from the twenty-seven Brazilian states and to analyze the spatial distribution of these variables. **Material and Methods:** This was an ecological study using secondary data from the National Epidemiological Oral Health Survey 2010 and from the United Nations Development Program. Human development was measured by the Human Development Index (HDI) and dental caries by the Decayed, Missing and Filled Teeth index (DMFT). Dental caries prevalence and experience at the age of 12, and state HDI were entered into Google Sheets® and Google My Maps® for map creation. Data were analyzed by Pearson's correlation (HDI and DMFT, DMFT individual components, prevalence of dental caries and prevalence of dental pain) ( $p < 0.05$ ). **Results:** Prevalence of dental caries ranged from 37.3% to 78.2% among the states. Dental caries was more prevalent in Rondônia (78.2%) and less prevalent in Santa Catarina (37.3%). Mean DMFT ranged from 1.06 to 4.81, with the highest value in Rondônia (4.81) and the lowest in Distrito Federal (1.06). HDI ranged from 0.631 (Alagoas) to 0.863 (Distrito Federal). There were negative correlations between HDI and dental caries ( $r = -0.504$ ), dental caries experience ( $r = -0.459$ ), decayed ( $r = -0.441$ ) and missing ( $r = -0.441$ ) components of the DMFT ( $p < 0.05$ ). **Conclusion:** Higher human development of the region lower dental caries experience and prevalence in 12-year-old Brazilian schoolchildren.

**Keywords:** Dental Caries; Oral Health; Epidemiology; Prevalence.

## Introduction

Dental caries remains a public health issue in Brazil due to its high prevalence. Data from the last National Epidemiological Survey (SB Brazil 2010) revealed that 56.5% of the 12-year-old children surveyed had at least one permanent tooth with a history of decay [1], which corresponds to twice the limits advocated by the WHO for this age-index [2]. These findings are worrisome, particularly because dental caries leads to significant functional and psychosocial distress on the individual's quality of life. Evidence has suggested that 12-year-old children with caries experience have a poorer oral health-related quality of life than those who are caries-free [3,4].

Dental caries affects unequally populations of different socioeconomic levels worldwide, with a higher prevalence in areas with poorer socioeconomic indicators [5,6]. In Brazil, a high socioeconomic status is directly associated with a decrease in one's susceptibility to dental caries, while a higher incidence of the disease is associated with attending public schools, low family income, and low schooling of the parents [7].

In 2011, the Ministry of Health of Brazil sponsored a National Epidemiological Oral Health Survey, named SB Brazil 2010. One of the goals of this survey was to estimate the prevalence and severity of dental caries in the population aged 5, 12, 15 to 19, 35 to 44 and 65 to 74 years. The project was developed to establish an oral health survey nationwide using the methodology suggested by the World Health Organization (WHO) [1,8,9].

The Human Development Index (HDI) provides a quantitative measure and comparability of the standards of living of nations or regions based on income, education and health parameters to enable the analysis of human development. The HDI has been considered a good correlation variable for indicators associated with health outcomes. In addition, the HDI has indicated that the health-disease balance in different populations is a result of their quality of life conditions [10]. A study carried out in Brazil revealed that 12-year-old children living in places with a low HDI have a high mean decayed, missing and filled teeth (DMFT) index and that the HDI is strongly associated with both the percentage of caries-free teeth and the DMFT index [4]. Similarly, another study found an association between the DMFT index and HDI in 99 countries [11].

It is known that one's social condition can be considered a relevant parameter justifying their oral health status. In fact, socioeconomic changes play an important role in decreasing the incidence and prevalence rates of dental caries [12]. A study carried out with data from 18 industrialized countries showed that between 1970 and 1980, social factors accounted for a 65% reduction of dental caries in 12-year-old children [13]. Some studies have investigated the association between dental caries and social development in both the ecological and individual fields and have shown that the prevalence of caries based on the DMFT index is higher in populations with low socioeconomic status [14-16]. To date, only one study has evaluated the association between HDI and dental caries with nationwide representative data. However, this study only considered the data concerning the capitals of the Brazilian states [4].

This study aimed to investigate the correlation between human development and dental caries in 12-year-old Brazilian schoolchildren and to analyze the spatial distribution of these variables nationwide.

## Material and Methods

### Study Design and Sample Characteristics

This was an ecological study using secondary data from two national surveys in Brazil, namely: National Epidemiological Oral Health Survey (SB Brazil 2010) and the CENSO 2010 (population census). The

HDI data were obtained from the CENSO 2010 whereas clinical data (experience and prevalence of dental caries) were obtained from the SB Brazil 2010.

SB Brazil 2010 contains epidemiological information on the oral health of the Brazilian population with representation for the state capitals, the Federal District and the five natural regions of Brazil (north, northeast, southeast, south and center-west). This division was made because state capitals together hold nearly a quarter of the population of the entire country and concentrate most of the economic activity.

SB Brazil 2010 was considered a nationwide project through which 37,519 individuals were examined. Of these, 7,247 were 12-year-old children from all 27 Brazilian states. A total of 177 municipalities were included in the sampling plan: all capitals and 150 municipalities in the interior. Oral examinations were performed to determine the prevalence and severity of main oral conditions. In addition, questionnaires were used to collect information on socioeconomic status, access to and use of dental services as well as perceived health [1].

#### Training and Calibration of Examiners

The fieldwork teams recruited for SB Brasil 2010 were previously trained and calibrated. The teams were composed of an examiner and a scorer and received training through workshops for a total of 32 hours. The workshops covered topics such as the operational details of the survey, understanding the characteristics of each participant and discussing the theoretical and practical aspects of the indices that were used, in order to guarantee uniformity in the procedures. The calibration step aimed to simulate the conditions that the teams would find in the field work. The consensus calibration technique was used, in which the coefficients of agreement of each examiner were calculated as well as the results obtained by consensus. The minimum acceptable value for the concordance rate among the examiners was 0.65, as proposed by the WHO [1,17].

#### Data Collection

The Human Development Index (HDI) compares the standards of living of countries or regions. It is based on three parameters, namely: education, *per capita* income and longevity [18]. The purpose of the HDI is to provide a more comprehensive indicator in addition to the Gross Domestic Product (GDP) *per capita*, whose only objective is to measure the economic dimension of development [10].

In our study, the HDI of all Brazilian states in 2010 were obtained from the United Nations Development Program (UNDP) website. The HDI data collection was performed through the 2010 population census (CENSO 2010) by the Brazilian Institute of Geography and Statistics (IBGE). It is a population census program designed to measure the socioeconomic conditions of the population and their households. The census covered 5,565 municipalities and 67,569,688 households, where information concerning work, income and education was collected via questionnaires [19].

Caries prevalence, DMFT index (decayed, missing and filled teeth index) and dental pain prevalence data were obtained from SB Brazil 2010 databank. The diagnosis of dental caries followed the WHO guidelines [1,8].

Data collected were entered into Google Spreadsheets® (Google Inc. Mountain View, CA, USA), analyzed and plotted into a graph. The findings were also used to generate a map on Google My Maps® tool (Google Inc. Mountain View, CA, USA).

#### Data Analysis

Data were analyzed using IBM SPSS® statistics software (SPSS for Windows, version 25.0, IBM Inc., Armonk, New York, USA). The units of analysis in the present study were the Brazilian states, which include data from all 177 municipalities included in the SB Brasil 2010 project. The data were analyzed descriptively and checked for normality by the Kolmogorov-Smirnov test ( $p < 0.05$ ), which indicated normal distribution of all variables. Pearson's correlation test was used to check the correlation between HDI and prevalence of dental caries, prevalence of dental pain, DMFT index and its individual components (D, M and F) with a 5% significance level. All variables were treated as quantitative.

#### Google Spreadsheets, Google Docs and Google My Maps

Google Spreadsheet is an important online collaboration tool available in Google Docs to manage files. It performs various functions not available in Microsoft Excel, such as storing information collected from Google Forms online. Google Forms is an online tool for academics to conduct surveys and questionnaires [20]. Data extracted from SB Brasil 2010 and UNDP were stored into Google Spreadsheet and organized so that the tool can interpret and display the information on a map, which was generated through the Google My Maps platform.

#### Quantum GIS (QGIS)

Geographic information systems (GIS) have been adopted by the industry and public administration for their ability to heterogeneously integrate, analyze and visualize digital data. QGIS is one of the most popular GIS tools, which has a low cost and has been widely used in education for spatial information creation, editing, analysis and mapping [21].

The QGIS was used in our study to obtain individual images of the shapes of all Brazilian states. To do so, it was necessary to download the shapes from the IBGE website, following the "interactive" maps section, "files" menu and "download shapefiles" submenu. The Brazilian states shapes were cut accordingly through the QGIS tool and imported into Google My Maps, where they were merged with the information stored in the Google Spreadsheets' worksheet.

#### Ethical Issues

The SB Brasil 2010 survey was executed in accordance with Resolution 196/96 of the National Health Council (CNS) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. It was submitted and approved by the Human Research Ethics Committee of the Ministry of Health, under protocol number 15.498. All parents or legal guardians signed an informed consent form agreeing to participate in SB Brasil 2010 as well as authorizing the clinical examination of their children.

According to Law No. 5,534, of 1968, any natural or legal person governed by public or private law that is under the jurisdiction of Brazilian law is obliged to provide the information requested by the IBGE. In addition, this same law guarantees the confidentiality of the information and that it will be used exclusively for statistical purposes, subject to summary dismissal and criminal prosecution of violator of census confidentiality.

#### Results

The prevalence of dental caries varied significantly among the states, with a minimum of 37.3% in the state of Santa Catarina and a maximum of 78.2% in Rondônia. Mean DMFT index ranged from 1.06 to 4.81, with the highest values in Rondônia (4.81) and Maranhão (3.55), and the lowest in Distrito Federal (1.06) and

Santa Catarina (1.07). The decayed (D) component of the DMFT index ranged from 0.52 (Distrito Federal) to 3.55 (Rondônia), while the missing (M) component ranged from 0.01 (Mato Grosso do Sul) to 0.31 (Mato Grosso), and the filled (F) component varied from 0.13 (Goiás) to 1.22 (Mato Grosso). The lowest prevalence of dental pain observed was 10.6% (Sergipe), whereas the highest prevalence was 36.7% (Mato Grosso). HDI ranged from 0.631 to 0.863 in the states of Alagoas and Distrito Federal, respectively (Table 1). There was a moderate negative correlation between caries prevalence and HDI ( $r=-0.504$ ,  $p=0.007$ ) as well as between the mean DMFT index and HDI ( $r=-0.459$ ,  $p=0.016$ ). With regard to the individual components of DMFT, there were also moderate negative correlations between the decayed component (D) and HDI ( $r=-0.518$ ,  $p=0.006$ ) and between the missing (M) component and HDI ( $r=-0.441$ ,  $p=0.021$ ). HDI was neither significantly correlated with the filled (F) component of the DMFT index ( $r=-0.068$ ,  $p=0.738$ ) nor with the prevalence of dental pain ( $r=0.063$ ,  $p=0.755$ ).

The data obtained from the SB Brazil 2010 epidemiological survey and UNDP are described in Figure 1. Light red markers show a lower prevalence of dental caries in dark blue-colored states corresponding to higher HDI values.

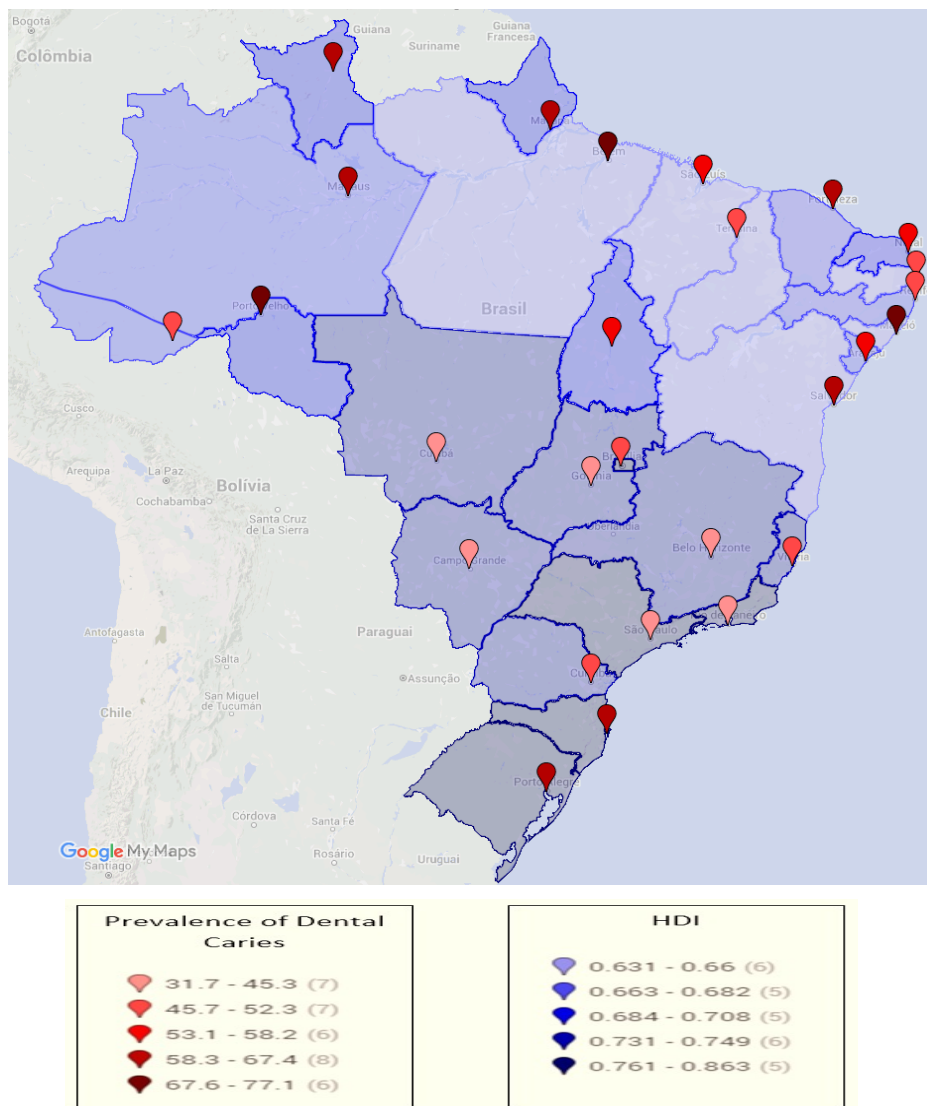


Figure 1. Graphical analysis of the prevalence of dental caries in 12-year-old schoolchildren and the HDI of Brazilian states.

**Table 1. Mean DMFT\*, mean DMFT components, prevalence of dental caries and dental pain; and HDI in all Brazilian states, 2010.**

State	Mean DMFT	Mean D component	Mean M component	Mean F component	Prevalence of Dental Caries (%)	Prevalence of Dental Pain (%)	HDI
Rondônia	4.81	3.55	0.24	1.02	78.2	26.4	0.690
Acre	2.52	1.40	0.20	0.92	71.5	26.3	0.663
Amazonas	2.81	2.08	0.21	0.52	70.1	31.4	0.674
Roraima	2.84	1.82	0.14	0.88	73.2	29.0	0.707
Pará	2.62	2.02	0.19	0.41	67.5	25.1	0.646
Amapá	2.50	1.70	0.15	0.64	70.7	27.7	0.708
Tocantins	2.43	1.54	0.19	0.69	68.4	26.4	0.699
Maranhão	3.55	2.60	0.19	0.76	73.0	16.2	0.639
Piauí	1.78	1.12	0.05	0.61	53.0	19.6	0.646
Ceará	1.94	1.22	0.19	0.53	55.1	23.2	0.682
Rio Grande do Norte	2.14	1.36	0.11	0.67	57.7	25.8	0.684
Paraíba	2.70	1.38	0.13	1.19	70.5	20.0	0.658
Pernambuco	1.77	0.99	0.18	0.60	58.4	23.5	0.673
Alagoas	2.37	1.77	0.09	0.51	60.3	20.6	0.631
Sergipe	1.32	0.81	0.11	0.40	43.6	10.6	0.665
Bahia	1.55	1.11	0.09	0.35	50.3	23.5	0.660
Minas Gerais	1.57	0.89	0.03	0.65	50.5	24.8	0.731
Espírito Santo	1.36	0.76	0.04	0.56	51.1	29.1	0.740
Rio de Janeiro	1.38	0.68	0.06	0.64	47.8	12.9	0.761
São Paulo	1.53	0.71	0.16	0.66	49.3	27.6	0.783
Mato Grosso do Sul	1.77	0.85	0.01	0.91	59.3	19.6	0.740
Mato Grosso	3.06	1.53	0.31	1.22	68.0	36.7	0.732
Goiás	2.34	1.39	0.05	0.13	60.5	24.0	0.742
Distrito Federal	1.06	0.52	0.02	0.52	41.5	18.5	0.863
Paraná	1.92	0.91	0.03	0.98	60.9	23.7	0.749
Santa Catarina	1.07	0.69	0.02	0.36	37.3	21.0	0.773
Rio Grande do Sul	1.72	1.16	0.06	0.50	54.0	26.5	0.769

\*DMFT= Decayed, Missing, Filled Teeth; \*\*HDI= Human Development Index.

## Discussion

The HDI ranges from 0 (no human development) to 1 (complete human development). It is considered low, medium and high when the values are between 0 and 0.499, 0.5 and 0.799, and 0.8 and 1, respectively [22]. In the present study, the HDI presented values between 0.631 and 0.863, which are considered indicative of medium to high human development. As shown in our study, there was a high prevalence of dental caries in 12-year-old children in Brazil. For instance, 78.2% of the children examined in the state of Rondônia had a high prevalence of the disease.

Dental caries is a highly prevalent disease worldwide, mainly affecting children. Its etiology is closely related to the occurrence of bacterial biofilms on the tooth surface resulting from the breakdown of fermentable dietary carbohydrates [23]. In addition to these biological determinants, dental caries is also associated with socioeconomic conditions [24,25]. The results of our study corroborate this statement, since a higher prevalence of caries was found in states whose HDI was lower. The association between HDI and dental caries was also observed in a study using data from several countries. The authors observed a high caries experience in 12-year-old children from low HDI countries [26].

The caries experience is subject to sociodemographic and geographical inequalities. There was a great discrepancy in the distribution of caries between the states of Brazil, in that higher caries experience were found in Northern and Northeastern states as compared to the other regions. The worse socioeconomic conditions in the North and Northeast regions may explain the differences in the oral health condition of surveyed children. In Brazil, lower income has been associated with high consumption of carbohydrates, restricted use of fluoridated toothpaste, as well as poor access to dental care [27]. The link between lower income and poor access to dental care is also demonstrated by the negative correlation between HDI and D and M components of DMFT. The lower the HDI, the higher mean D and M components. Moreover, it should be noted that, in general, the D component was the one that most contributed to the DMFT index. These results highlight an unmet need of dental treatment among included children, especially among those from less developed states.

A previous study found that municipalities in the North and Northeast regions had lower Human Development Index by Municipality (HDI-M) than those in the South and Southeast regions, and few of them had treated water and public fluoridated water supply. Students living in municipalities with higher HDI-M and with public fluoridated water supply had a lower chance of experiencing caries when compared to those living in cities with lower fluoridated water coverage and lower HDI-M [28]. According to these authors, regions with high social inequality reflect the lack of investments in public health policies and have little support for oral health care of the population, e.g. water fluoridation or access to fluoridated toothpaste. On the other hand, it was observed that adolescents with higher caries experience frequently fail to attend dental care appointments, especially those regarding health prevention actions [29,30].

Ecological studies investigate health outcomes from an environmental background to understand how it affects the health of individuals and groups. This type of study has the advantage of using secondary data as a database, besides the low cost and the simplicity of the analysis [31]. Our study focused on an ecological and contextual approach on the prevalence of caries and HDI. According to the authors [32], ecological studies can be used, for example, to examine structural or sociological effects of human behavior in concomitance with a disease. Ecological studies measure the association at the environmental level and may also provide measures on the effects of the environment on a health condition. In addition, studies with ecological design can be of

great relevance for driving health policies and also for evaluating the impact of interventions on the population's health [32].

Despite the advantages, ecological studies have as main disadvantage the impossibility of making causal inferences at the individual level, since the object studied is a population group, otherwise it falls into an ecological fallacy. As the individuals who were examined for caries are not necessarily the same ones who answered the sociodemographic questionnaires, it is not possible to state that the individuals with the highest caries indices were exactly those with worse socioeconomic conditions. In addition, the use of secondary data (SB Brazil 2010) represents another limitation of the present study, since it makes it impossible to guarantee the quality and reliability of the data. The use of different data sources also generates a great variation in the quality of information [33,34].

Given the moderate correlation between the outcomes, it can be stated that an individual living in a city with a higher HDI will not necessarily have a low prevalence of caries and vice versa. For instance, the state of Mato Grosso has a moderate HDI and a very high prevalence of caries among 12-year-old schoolchildren. The opposite can be seen in the state of Piauí, which has an HDI lower than that of the state of Mato Grosso but showed a lower prevalence of caries.








Our study used the Google My Maps® mapping feature as a graphical analysis methodology. This feature allowed the main search results to be represented on a map (Figure 1). The prevalence of caries was represented by markers with different shades of red and the HDI was represented with filling of different tones of blue for each state. This tool facilitated the understanding of the findings, is free and can be used in future research.

Lastly, the present study included a probabilistic and representative sample, which increases the reliability of the results. The findings reported herein may be used to conduct comparative studies with 12-year-old schoolchildren in other countries and may likewise contribute to surveillance policies, public health programs, and to assist in decision-making regarding the allocation of public resources.

## Conclusion

In Brazil, the prevalence of dental caries and DMFT index among 12-year-old schoolchildren varied based on the HDI of the state where they lived. Overall, states with higher HDI showed better caries outcomes (lower prevalence and lower experience at the age of 12).

## Authors' Contributions

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All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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## Conflict of Interest

The authors declare no conflicts of interest.

## Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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