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## Edentulism in Brazil: trends, projections and expectations until 2040

### Edentulismo no Brasil: tendências, projeções e expectativas até 2040

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**Abstract** *The aim of this study was to examine the edentulism rates in Brazil and make projections for the next years. Data were collected from three national oral health surveys. The percentage of edentulous jaws was calculated. Projections were made for the years 2020, 2030 and 2040, assuming that edentulism follows a logistic function. Population projections were also performed. Annual change in proportion of edentulous jaws was -0.04% for teenagers, -0.96% for adults and 0.76% for the elderly. By 2040, edentulous jaws will be virtually zero among teenagers, 1.77% among adults and 85.96% among the elderly. Teenagers will slightly decrease in number; adults will increase and subsequently decrease; the elderly will continue to increase. In teenagers and adults, the number of edentulous jaws will decrease, being approximately 616,000 in 2040. In the elderly, it will increase alarmingly, reaching over 64 million in 2040. Edentulism is declining in Brazil among teenagers and middle-aged adults, but is still increasing and will continue to increase for the next decades among the elderly.*

**Key words** *Epidemiology, Oral health, Public health, Health statistics, Tooth loss*

**Resumo** *O objetivo deste estudo foi examinar as taxas de edentulismo no Brasil e fazer projeções para os próximos anos. Os dados foram coletados de três censos nacionais de saúde bucal. O percentual de arcadas edêntulas foi calculado. Foram feitas projeções para 2020, 2030 e 2040, assumindo que o edentulismo segue uma função logística. Também foram realizadas projeções populacionais. A variação anual da proporção de arcadas edêntulas foi de -0,04% para jovens, -0,96% para adultos e 0,76% para idosos. Até 2040, o percentual de arcadas edêntulas será virtualmente zero entre jovens, 1,77% entre adultos e 85,96% entre idosos. O número de jovens vai diminuir levemente; o de adultos vai aumentar e depois diminuir; e o de idosos vai continuar aumentando. Para jovens e adultos, o número de arcadas edêntulas vai diminuir, aproximando-se de 616.000 em 2040. Para os idosos, este número vai aumentar alarmantemente, alcançando mais de 64 milhões em 2040. O edentulismo está diminuindo no Brasil entre jovens e adultos, mas está aumentando e continuará a aumentar nas próximas décadas entre os idosos.*

**Palavras-chave** *Epidemiologia, Saúde bucal, Saúde pública, Estatísticas de saúde, Perda de dente*

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## Introduction

Over the last several decades, some oral health indicators, especially for dental caries, have improved in Brazil. DMFT (decayed/missing/filled teeth) at 12 years, for example, reduced from 2.78 in 2003 to 2.07 in 2010<sup>1,2</sup>. Considering the DMFT index, Brazil is ranked in an intermediate position among the countries of the same level of development in Europe and America, and presents the best values in South America<sup>1,3</sup>.

Tooth loss is a complex phenomenon that involves not only biological factors, but also cultural, economic and social factors<sup>4,5</sup>. The belief in tooth loss as a natural consequence of aging leads individuals to neglect oral care and to gradually replace natural teeth for dental prostheses. Other aspects are related to attitudes of dental professionals and to the inability of public health system to meet the demand of the population for dental treatment. For an important part of the population that do not have access to private dental offices, the only possible treatment is tooth extraction. As dental caries disease is the main cause of tooth extraction<sup>6</sup>, one can expect that a decline in caries may be accompanied by decline in tooth loss, and consequently, by decline in edentulism. In fact, there is a trend towards reduction in edentulism in many countries<sup>7</sup>. In the United States, the estimated rate of decline in edentulism is 1% per year<sup>8</sup>.

There is increasing edentulism with age, as the elderly population has experienced more episodes of tooth extraction throughout life, and consequently the percentage is higher<sup>9,10</sup>. Parallel to the decline of edentulism, industrialized countries face population aging, due to decrease in fertility and mortality rates, which leads to an increase in life expectancy<sup>11</sup>. The trends of edentulism and the possible impact of these two phenomena – decline in edentulism rates and population aging – on the future expectations of the number of edentulous individuals have not been studied in Brazil.

Douglass *et al.*<sup>8</sup> estimated that although edentulism rates will decline in the United States over the next few years, the elderly population will increase and surpass this decline. The authors have made projections until the year 2020 and have shown that the absolute number of edentulous jaws will increase from 53.8 million in 1991 to 61.0 million in 2020. Their work refutes the thought that there would shortly be no need for complete dentures in the United States. On the contrary, the American denture market

will increase. Similar projections were made for Finland, Sweden and the United Kingdom, but they revealed an inverse trend – all these countries will experience a contraction of their denture market<sup>12</sup>. For New Zealand, Thomson has demonstrated that edentulism rates are falling, following a logistic decline (an S-shaped curve); however, the author has not correlated these rates to population projections<sup>13</sup>. This type of study has not yet been conducted in Brazil.

Edentulism rates are an important indicator of the operation of a country's oral health care system and therefore it is essential to monitor its occurrence. Studying edentulism trends makes it possible to diagnose the oral health status of the population and thus plan government actions to improve it. Therefore, the aim of this study was to examine the behavior of edentulism rates in the Brazilian population over the last several decades and make projections for the coming years, relating them to population aging.

## Methods

Data on the prevalence of edentulism in Brazil were collected from three national oral health surveys conducted in 1986, 2003 and 2010<sup>1,2,14</sup>. The 1986 survey was the first epidemiological oral health survey of national coverage in Brazil. It was carried out in 16 state capitals, representing the five geographic regions (North, Northeast, South, Southeast and Midwest). The 2003 survey (the first survey of a project called 'SB Brasil') was conducted in 250 cities of different population sizes, totaling more than 108,000 individuals. The 2010 survey (the second survey of 'SB Brasil' Project) was the most recent, and was conducted in the urban areas of 177 cities (all the 27 state capitals and 30 cities in the interior of each state), totaling over 37,000 individuals.

In the three surveys, edentulism was assessed for three age groups. In 2003 and 2010 surveys the groups were defined by World Health Organization (WHO) criteria, and included 15-19 years of age, 35-44 years of age and 65-74 years of age. In 1986 survey the first two groups were the same, but the third group was 50-59 years of age, due to the lower life expectancy at that time. Therefore, in the present study we have considered the groups: teenagers, adults and the elderly.

There is little standardization in the manner that data are presented in the surveys. The 1986 survey presents individuals (number and percentage) who wear or need complete dentures

in the maxillary jaw, mandibular jaw or both. The 2003 survey presents individuals who wear or need complete dentures in each jaw. The 2010 survey presents individuals who wear complete dentures in each jaw or who need them in one or both jaws. To standardize the data for this study, the percentage of edentulous jaws was considered, rather than the number of edentulous individuals.

To calculate the percentage of edentulous jaws, the percentage of individuals who wear or need dentures in the maxilla or in the mandible were added and divided by two (since each individual has two jaws). The number of persons in each age group was collected from the national censuses or from the National Survey by Household Sample (PNAD, in Portuguese) from 1978 to 2010 (available online at <http://www.ibge.gov.br>).

### Statistical analysis

From the data collected on the percentage of edentulous jaws, projections were made for the years 2020, 2030 and 2040, assuming that edentulism behavior follows a logistic function<sup>15</sup> and that the same trends would continue until 2040. Logistic regression uses a binary dependent variable (in this case, edentulous or non-edentulous jaws). The logistic regression model formula is  $\log(p/(1-p))=a+b \times Y$ , where Y is the year (independent variable) and a and b the estimated constant and intercept of the model. The dependent variable was constructed by creating 1000 observations for each year (observing the proportion given by the surveys) and assigning 1 to eden-

tulous jaws or 0 to non-edentulous jaws (for an example, see Table 2 in Osterberg et al.<sup>15</sup>). In this manner, a data set of six observations could be constructed and the parameters of the model estimated to extrapolate the values to future years.

To estimate the absolute number of edentulous jaws in 2020, 2030 and 2040, it was necessary to make population projections for these years for each age group. With 17 observations (given by the censuses) it was possible to find the model that best fitted the data, which was the polynomial quadratic model for the teenager group, and the polynomial cubic model for adults and the elderly groups. With the estimated parameters for these models, the values could be predicted for the desired future years.

The regression models used here were applied only as a way of finding an equation to predict the percentage of edentulism and the population number for future years. Therefore, the significance of the model or the significance of its parameters was of no interest in this study.

### Results

Table 1 shows the percentage of edentulous jaws, the population number and the absolute number of edentulous jaws for teenagers, adults and the elderly, extracted from national surveys until 2010, and predicted values from 2020 to 2040.

From 1986 to 2010, the edentulism rates have declined for teenagers and adults, and this decline is more pronounced in the latter. Whereas, edentulism has increased in the elderly. The

**Table 1.** Percentage and absolute number of edentulous jaws, and population number in Brazil (prevalent and predicted).

	1986	2003	2010	2020	2030	2040
Percentage of edentulous jaws (%)						
Teenagers	1.01	0.07	0.1	0.0087	0.0022	0.0005
Adults	29.52	18.61	6.49	5.59	3.16	1.77
Elderly	58.91	61.35	77.15	77.64	82.18	85.96
Population number						
Teenagers	14016591	17250730	16990872	17327120	16056680	13810840
Adults	14913051	24158531	26897943	28597700	25949590	17393710
Elderly*	6102738	11527410	14081477	19755500	27319240	37289340
Number of edentulous jaws						
Teenagers	283135	24151	33982	3015	706	138
Adults	8804665	8991805	3491353	3197223	1640014	615737
Elderly	7190246	14144132	21727719	30676340	44901903	64107833

\* over 65 years of age

annual change in the proportion of edentulous jaws was -0.04% for teenagers, -0.96% for adults and 0.76% for the elderly. The projections show that by 2040, edentulous jaws will be virtually zero among teenagers, 1.77% among adults and 85.96% among the elderly. Figure 1 shows the percentage of edentulous jaws for the three age groups.

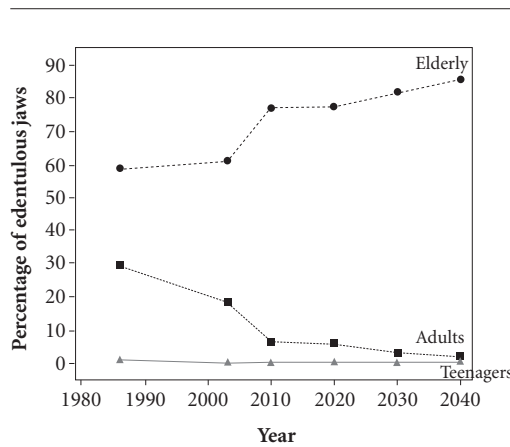
Population projections show a slight decrease in the number of teenagers up to 2040. Adults will increase in number and subsequently decrease at some point between 2020 and 2030, but in 2040 there will be a slightly higher number than there were in 1986. The elderly are the fastest growing population group; it will continue to increase un-

til 2040, reaching over 37 million of individuals. These trends are shown in Figure 2.

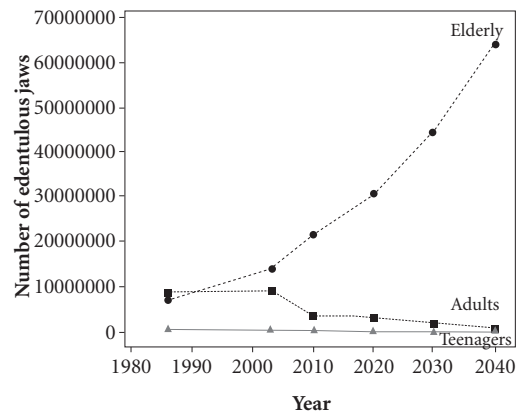
The number of edentulous jaws (called 'denture market') will decrease for teenagers and adults, being approximately 616,000 for the two groups in 2040. For the elderly, however, the number of edentulous jaws will increase alarmingly, reaching over 64 million in 2040 (Figure 3).

**Discussion**

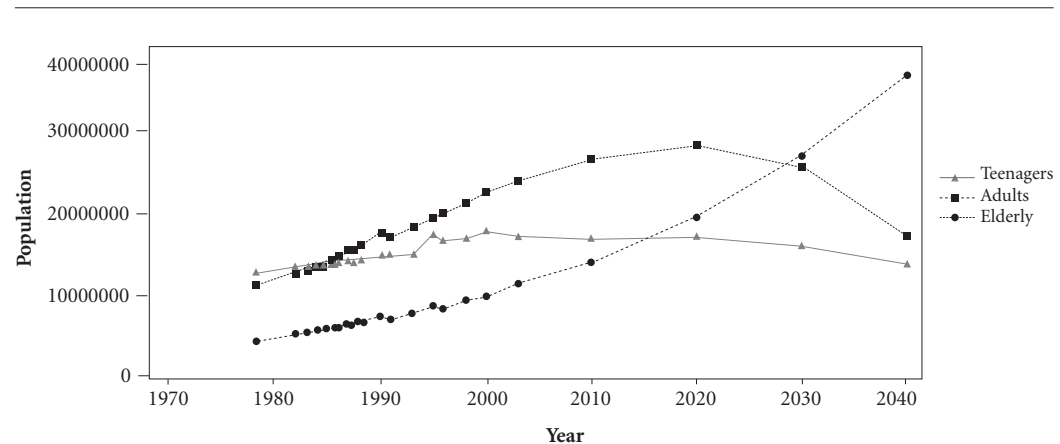
Edentulism is an extreme oral condition that affects nutrition<sup>16</sup>, esthetics<sup>17</sup> and the self-esteem<sup>7</sup> of individuals, decreasing their quality of life<sup>18</sup>. It



**Figure 1.** Percentage of edentulous jaws for the three age groups.



**Figure 3.** Number of edentulous jaws for the three age groups.



**Figure 2.** Population trends and projections until 2040 by age groups.

is considered an effective marker of population oral health<sup>12</sup>. Brazil, one of the most important countries in South-America, still presents a high prevalence of edentulism<sup>9</sup>. However, this condition is not sufficiently monitored at a national level.

In the present study, data related to edentulism obtained from the three national oral health surveys conducted in Brazil, from 1986 to 2010 were assessed, and projections were made until the year 2040. In Brazil there is a decline in edentulism among the teenagers (15-19 years of age) and the middle-aged adults (35-44 years of age), and it will be near to zero by 2040 in these age groups. The same trend was observed in the United States<sup>8</sup>, United Kingdom, Finland, Sweden<sup>12,15</sup> and New Zealand<sup>13</sup>. The annual rate of decline among the adults is about 1%, similar to that in the United States and Sweden<sup>8,12</sup>. This decline began before 1986 and is probably due to public policies to reduce dental caries, especially water supply fluoridation, which attained a significant portion of the population in the 1990s<sup>4</sup>.

The decline in edentulism is not observed among older people (65-74 years of age). On the contrary, in this age group, edentulism is increasing and will continue to increase until 2040. This increase, coupled with population aging, will lead to an elevated number of edentulous individuals in the future, reaching over 64 million edentulous jaws in 2040. Although the percentage of edentulism among the elderly was already high compared with other age groups in 1986, the absolute number of edentulous jaws was relatively low. With the relative increase in the elderly population, the number of edentulous jaws has markedly increased in this age group. These trends reflect the historical focus of public oral health care for adults on urgent care, which often involves tooth extractions. Although there has been an improvement in the oral health status of the Brazilian population, it is a recent phenomenon, and the situation of elderly population has not yet been addressed. It should be noted that it was only after 2003 that endodontics and prosthesis – decisive specialties in treating severely injured teeth or replacing lost teeth – became part of the treatment options offered to the Brazilian population in the public oral health service<sup>4</sup>, and these services still reach only a small portion of the population.

The increase in percentage of edentulism among the elderly is not in agreement with the trends of decline observed in other countries. Even in the United States, where the projections

show that denture market will increase until 2020, the percentage of edentulism will decline<sup>8</sup>. The reason for the increase in the denture market in the United States is that there will be a higher rate of population growing older than the rate of decline in edentulism, and the ‘baby boom’ is the probable explanation for this fact. Edentulism may initially increase and later decrease<sup>19</sup>, and then the differences among countries may reflect different stages of a similar trend. Presumably, the improvements in oral health began earlier in Europe and United States than in Brazil.

This study has some limitations. The first is the scarcity of national surveys on oral health in Brazil. Only three surveys of national coverage have addressed edentulism, and this is not sufficient to show a tendency. For this reason, we had to assume that edentulism in Brazil follows the same logistic function that has been shown for other countries. The lack of this type of survey is a fact in many countries. Few countries worldwide conduct them, and fewer do so regularly. Another limitation is the age of the elderly group in the 1986 survey (50-59 years of age), which was lower than the age considered in the later surveys (65-74 years of age). This may have reduced the prevalence of edentulism for that year. Although in some aspects there was little standardization among the surveys, samples were large and nationally representative, and thus there was enough statistical power to assess trends.

Making predictions is a complex procedure. Our predictions were based only on statistical tendencies, not considering social factors that could influence the data. Although our projections of the population did not consider factors such birth and mortality rates or migration, the polynomial function used in our study is the same function used by Brazilian Institute of Geography and Statistics (IBGE, in Portuguese) to make population projections. With regard to the projection of edentulism, we assumed that the same trends observed until 2010 would continue until 2040. However, improvements in the oral health care systems, in addition to the possible advances in economics and education, could result in a less pronounced increase in edentulism among the elderly than shown in this study.

In conclusion, this study has shown that edentulism is declining in Brazil among teenagers and middle-aged adults, however, it will continue to increase among the elderly for the next decades, as the rate between older and younger people has risen since 1986. Even with its limitations, this study contributes to better under-

standing of the behavior of edentulism in Brazil, which is of utmost importance for the diagnosis, evaluation and planning of oral health care. It would also be interesting to assess the edentulism data considering factors such gender, skin color, per capita income, geographic area, educational level, frequency of dental visits, personal behav-

iors and access to health services, for example, as edentulism is known to be higher in women, ethnic minority groups, individuals living in rural areas and in areas with non-fluorinated water, with low income, poor education, and in the presence of such behaviors like smoke or low frequency of dental visits<sup>4,20-22</sup>.

### **Collaborations**

M Cardoso: analysis and interpretation of data and writing of the article. I Balducci: analysis and interpretation of data and revision of the article. DM Telles: conception of the idea, data analysis and revision of the article. EJV Lourenço: conception of the idea and revision of the article. L Nogueira Júnior: data analysis and revision of the article.

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