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Methodological discussion about prevalence of the dental fluorosis on dental health surveys

ABSTRACT

OBJECTIVE: To evaluate the influence of social inequalities of individual and contextual nature on untreated dental caries in Brazilian children.

METHODS: The data on the prevalence of dental caries were obtained from the Brazilian Oral Health Survey (SBBrasil 2010) Project, an epidemiological survey of oral health with a representative sample for the country and each of the geographical micro-regions. Children aged five (n = 7,217) in 177 municipalities were examined and their parents/guardians completed a questionnaire. Contextual characteristics referring to the municipalities in 2010 (mean income, fluorodized water and proportion of residences with water supply) were supplied by the Brazilian Institute of Geography and Statistics – *Fundação Instituto Brasileiro de Geografia e Estatística*. Multilevel Poisson regression analysis models were used to assess associations.

RESULTS: The prevalence of non-treated dental caries was 48.2%; more than half of the sample had at least one deciduous tooth affected by dental caries. The index of dental caries in deciduous teeth was 2.41, with higher figures in the North and North East. Black and brown children and those from lower income families had a higher prevalence of untreated dental caries. With regards context, the mean income in the municipality and the addition of fluoride to the water supply were inversely associated with the prevalence of the outcome.

CONCLUSIONS: Inequalities in the prevalence of untreated dental caries remain, affecting deciduous teeth of children in Brazil. Planning public policies to promote oral health should consider the effect of contextual factors as a determinant of individual risk.

DESCRIPTORS: Fluorosis, Dental, epidemiology. Dental Health Surveys, methods. Reproducibility of Results. Oral Health.

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INTRODUCTION

Dental caries and its consequences continues to be a public health problem in many low and middle income countries and for socially disadvantaged groups in high income countries. However, the incidence and prevalence of dental caries has decreased significantly over the last few decades, especially in the young, an evident protective effect which can be attributed to the widespread use of fluoride.

The first research into the use of fluoride concentrated on its collective use in drinking water. Such research aimed not only to measure the preventative effects on the prevalence and incidence of dental caries, but also to establish safe levels in order to avoid dental fluorosis.[13,16] Systematic reviews of the literature of the last decade reaffirm the importance of using fluoride to prevent dental caries and recommend balancing the risks and benefits of collective and individual use of fluoride (topical use of fluoride).[14,19,27]

Dental fluorosis is defined as a change in the mineralization in the tooth enamel due to prolonged intake of fluoride during the period in which the teeth develop.[1,2] The majority of cases reported in the literature, including in Brazil, indicate mild or very mild occurrence of fluorosis which is, therefore, not considered to be a public health problem.[3,7,12,13]

Dean[8] describes the most commonly used method of clinically and epidemiologically classifying dental fluorosis. At the end of the 1970s, increased knowledge of the histological and microscopic characteristics of dental fluorosis enabled new methods of classification to be developed, among them the Thylstrup and Fejerskov index,[24] the Tooth Surface Index of Fluorosis (TSIF),[15] and the fluorosis Risk Index.[20] Selecting the appropriate index depends on the aim of the study, but the use of different indexes to establish the presence of fluorosis is a problem for the reliability and consistency of data on prevalence/incidence.

The SBBrasil 2003 (*Condições de Saúde Bucal da População Brasileira* - Oral Health Conditions in the Brazilian Population) and the *Pesquisa Nacional de Saúde Bucal* (Brazilian Oral Health Survey - SBBrasil 2010) are two nationwide surveys into oral health carred out in Brazil, and dental fluorosis was one of the health problems investigated. The SBBrasil 2010 was primarily an oral health monitoring strategy based on producing primary data, aiming to reinforce National Oral Health Care policies based on an epidemiologically based health care model.

The aim of this study was to analyze the limitations of the study of dental fluorosis in cross-sectional surveys.

METHODS

A quantitative based study with a descriptive and analytical approach, with data from the SBBrasil 2003 and SBBrasil 2010 studies. Based on this analysis, aspects of the reliability of the data obtained in the two surveys were discussed, as well as the accuracy of the estimates.

The data from the two above mentioned surveys were obtained from data bases available in the Brazilian Ministry of Health's General Coordination of Oral Health website. First, the database from the 2003 and 2010 databases were combined in order to analyze trends. The variable "year" was created in order to distinguish between the two databases and the final database had a total of 146 thousand records. Some of the variables were present in the 2003 survey and not in the 2010 survey, and vice-versa. In this case, if the variable was deemed to be important in the analysis, it was kept in the database and given a zero code in the year in which it did not appear. This was the case, for example, of the weighted variables which were only used in 2010.

As there were no weighted variables in 2003, the confidence intervals were calculated assuming a simple causal sample. In 2010 the confidence intervals were calculated taking into account design and weighting variables. Details of the sample design and the teams' training process for both surveys can be found in other publications.[a,b]

The index proposed by Dean[8] was used in the investigation of dental fluorosis in 12-year-old children. The outcome variable, the presence of fluorosis, was analyzed with a normal condition being considered based on a combination of "normal" and "questionable" scores and the other categories composed the prevalence of fluorosis, following the rules recommended in the 2003 and 2010 studies.

The distribution of the prevalence of fluorosis was shown according to the domains of the study (state capitals and regions) and the year studied (2003 and 2010). The confidence intervals (95%CI) were also shown for simple prevalence (without considering severity).

The data were analyzed using the SPSS version 17 statistics program. The first analysis of the data was conducted at an individual level (by year and by domain) and the behavior of the trend showed discrepancies and atypical observations.

In order to analyze the discrepant data (higher and lower), the following cutoff points for the prevalence of fluorosis

[a] Ministério da Saúde (BR), Secretaria de Atenção à Saúde, Departamento de Atenção Básica. Projeto SB Brasil 2003: condições de saúde bucal da população brasileira 2002-2003: resultados principais. Brasília (DF); 2005. (Série C. Projetos, Programas e Relatórios).
[b] Ministério da Saúde (BR), Secretaria de Atenção à Saúde. Projeto SB Brasil 2010 - Pesquisa Nacional de Saúde Bucal. Brasília (DF); 2009.

were established, with the minimum being from close to zero to 1.4% and the maximum being values above 30%, defined based on estimates of the prevalence of fluorosis for cities with and without fluoridated water. In cities where the water is not fluoridated there was expected to be a minimal prevalence of fluorosis due to exposure to fluoride from other sources, as well as genetic variations and individual variations in fluoride intake. Accordingly, cities with fluoridated water and regular control did not show a prevalence of fluorosis above 30%, even when other sources of fluoride are considered.[9]

Taking into account that there is a degree of imprecision inherent to the index used, the occurrence of random or systematic error ispossible.[5] This imprecision may be due to characteristics particular to the index or linked to deficiencies in the training and instruction process.

Therefore, in order to investigate the source of the error, the municipalities with the highest rates of prevalence in 2010 were analyzed, separating the values by census tract. Each examiner was responsible, on average, for three census tracts so that, when analyzed in isolation, the data could indicate bias in one or more examiners or, conversely, show that there was uniform bias between all of them.

Another aspect analyzed concerns the ideal sample size to be used in studies of the prevalence of fluorosis. The sample size for the 12-year-olds was calculated so as to estimate, with reasonable precision, rates of prevalence above 20%.[c] In general, the expected prevalence for fluorosis is well below this, so that, in order to obtain a good estimate "n" needs to be increased. Therefore, simulations were carried out aiming to estimate the minimum sample size necessary to observe the prevalence of fluorosis with more appropriate intervals of confidence. For this simulation, the expression given by the formula (1) was considered, in which the calculation of standard error includes design effect (d).

$$se\,(p) = \sqrt{d^2\,(p) \times \left(1\frac{n}{N}\right) \times \frac{p\,(100 - p)}{n}} \quad (1)$$

The SBBrasil 2010 Project followed the standards set by the Declaration of Helsinki and was approved by the National Council on Research Ethics, record no. 15,498, 7th January 2010.

RESULTS

Table 1 shows the distribution of rates of prevalence of fluorosis according to the domains of the study (state capitals and regions) and year (2003 and 2010). The 95%CI are also shown for simple prevalence (without considering severity).

Taking 2003 as the base year, Palmas (61%) in the North, Belo Horizonte (42%) in the Southeast and Curitiba (45%) in the South stand out. The prevalence in Palmas, for example, is so high that it caused the mean for the North (where fluoridated water supplies are scarce) to approach that of the South East (where all of the state capitals add fluoride to tap water).

Lack of fluorosis, or very low values should be viewed with caution, especially if the municipality provides fluoridated drinking water. This is the case in Florianópolis and Rio de Janeiro in 2003, with rates of prevalence of 1.05 and 1.4% respectively. On the other hand, Maceió, without a fluoridated tap water, had a prevalence of 16.3%.

Figures 1 and 2 show the data from Table 1 from different perspectives. Figure 1 shows prevalence ordered by year, with considerable variance in the prevalence, from 0% to 61% in 2003 and from 0% to 59% in 2010, highlighting those state capitals with atypical values, either for being very low (no fluorosis or, maximum 1.4%) or very high (over 30%).

Figure 2 shows the prevalence of fluorosis and respective 95%CI according to region and year. Figure 3 shows percentage difference between 2003 and 2010, with the former as the base year. Thus, positive numbers indicate an increase and negative number a decrease in prevalence.

In 2010, there appeared to be greater coherence between the prevalence of fluorosis and fluoridated water: municipalities without this had lower percentages. However, when the data for 2003 and 2010 are compared (Figure 3), the inconsistencies become evident. There were variations ranging from -100% in Boa Vista, in other words, fluorosis of 6.25 literally disappeared in 2010, to 1,540% (15 times higher) in Florianópolis, where fluorosis of 1% in 2003 climbed to 16.4% in 2010. In four state capitals with fluoridated water supplies (Palmas, Curitiba, Macapá and Brasília) there was a reduction in the prevalence of fluorosis between 2003 and 2010 and in five state capitals where the tap water is not fluoridated (João Pessoa, Cuiabá, Porto Velho, Manaus and Natal) increases between 74% and 210% were observed.

The data in Table 1 and Figure 1 show that, although the rates of prevalence seem to vary greatly between state capitals in terms of percentage points, these largely disappear when the interval estimates are considered. When the values for the prevalence are ordered as shown in Figure 1, it is possible to identify four groups of state capitals in which the prevalence does not vary statistically: (a) Rio Branco, Recife, Boa Vista, São Luís, Natal, Porto Velho, Cuiabá, Maceió, Macapá and João Pessoa, with rates of prevalence varying

[c] Ministério da Saúde (BR), Secretaria de Atenção à Saúde. Projeto SB Brasil 2010 - Pesquisa Nacional de Saúde Bucal. Brasília (DF); 2009.

Table 1. Distribution of prevalence of fluorosis according to study domain and year. SBBrasil 2003 and SBBrasil 2010.

Domain	2003			2010		
	n	Prevalence of fluorosis		n	Prevalence of fluorosis	
		%	95%CI		%	95%CI
Porto Velho	223	0.90	0.00;2.14	166	2.10	0.70;6.20
Rio Branco	268	0.00	0.00;0.00	172	0.00	0.00;0.00
Manaus	137	2.90	0.09;5.71	146	8.70	5.30;13.80
Boa Vista	240	6.70	3.54;9.86	205	0.00	0.00;0.00
Belém	338	3.60	1.61;5.59	251	26.60	18.10;37.30
Macapá	111	9.00	3.68;14.32	226	4.70	2.10;10.00
Palmas	246	60.60	54.59;66.71	176	11.10	7.30;16.40
North	9,857	9.20	8.63;9.77	1,702	10.40	7.10;15.00
São Luís	215	0.90	0.00;2.16	143	0.40	0.10;2.60
Teresina	248	2.00	0.26;3.74	191	17.70	12.00;25.40
Fortaleza	229	3.10	0.86;5.34	188	10.90	6.50;17.70
Natal	252	0.00	0.00;0.00	161	2.10	0.70;5.90
João Pessoa	282	4.60	2.15;7.05	139	8.00	2.40;23.80
Recife	149	1.30	0.00;3.12	197	0.00	0.00;0.00
Maceió	295	16.30	12.08;20.52	172	3.00	1.40;6.60
Aracaju	459	7.80	5.35;10.25	250	25.40	20.10;31.60
Salvador	317	7.60	4.68;10.52	255	44.30	32.70;56.50
Northeast	10,953	3.40	3.06;3.74	2,018	14.50	10.80;19.10
Belo Horizonte	336	42.00	36.72;47.28	262	58.60	50.30;66.50
Vitória	363	19.80	15.70;23.90	208	22.70	15.80;31.50
Rio de Janeiro	144	1.40	0.00;3.32	245	10.40	6.30;16.70
São Paulo	268	33.60	27.94;39.26	231	37.30	28.00;47.80
Southeast	10,924	11.70	11.10;12.30	1,331	19.10	14.30;24.90
Curitiba	322	44.70	39.27;50.13	267	11.20	6.40;18.90
Florianópolis	301	1.00	0.00;2.12	237	16.40	11.10;23.70
Porto Alegre	299	18.40	14.01;22.79	210	18.60	14.00;24.30
South	10,855	8.50	7.98;9.02	1,002	14.80	10.90;19.80
Campo Grande	203	6.90	3.41;10.39	206	12.60	8.40;18.50
Cuiabá	247	1.20	0.00;2.56	146	2.40	0.80;6.90
Goiânia	328	6.40	3.75;9.05	267	19.10	14.60;24.60
Brasília	178	16.90	11.39;22.41	195	13.70	7.90;22.80
Central-West	7,871	3.60	3.19;4.01	1,179	11.30	8.60;14.60
Brazil	50,460	7.40	5.00;10.90	7,232	16.70	13.80;20.10

between 0% and 8%; (b) Manaus, Rio de Janeiro, Fortaleza, Palmas, Curitiba, Campo Grande, Brasília, Florianópolis and Teresina, with values between 8.7% and 17.7%; (c) Porto Alegre, Goiânia, Vitória, Aracaju and Belém, varying between 18.6% and 26.6%; and (d) São Paulo, Salvador and Belo Horizonte, with rates of prevalence between 37.3% and 58.6%.

When analyzing the prevalence of fluorosis and considering the distribution of the tracts in the state capitals, it can be observed that in one of the municipalities, where the general prevalence was 27%, almost all of this percentage (21%) was located in 1/3 of the 30 assessed tracts, for which the data were obtained by five examiners. When data considered to be outliers and pertaining to these examiners were excluded the prevalence fell to 6.7%. On the other hand, in another municipality, there was no concentration of high prevalence in any tract. In half of the tracts the values were above the mean (58%) and variation between the examiners was not considered to be significant.

Table 2 shows standard errors and 95%CI for estimates of prevalence based on different sample sizes for a

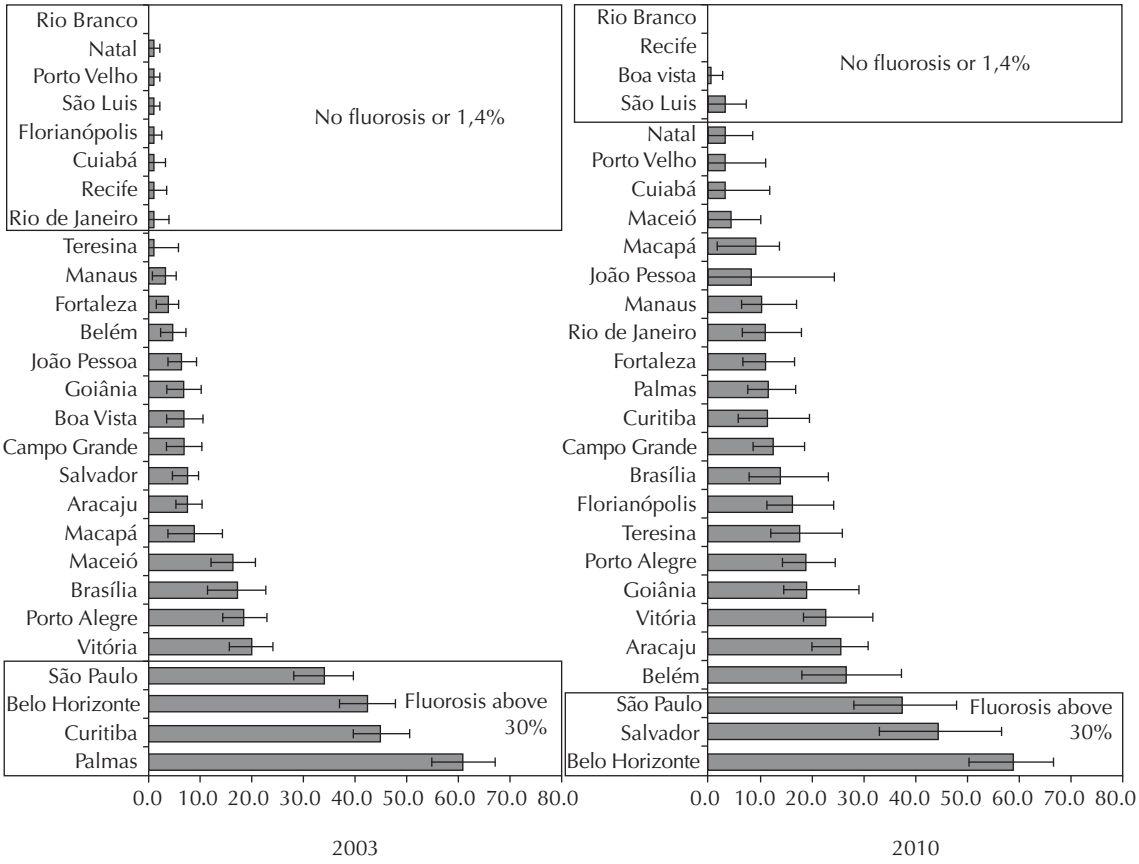

Figure 1. Prevalence of fluorosis according to domain and year. SBBrasil 2003 and SBBrasil 2010.

design effect equal to 2. Taking a minimum coefficient of variation of 15% as the parameter for decision making, as in the SBBrasil 2010, the minimum sample size would be1,500 individuals and the confidence interval between 3.4% and 6.6%.

DISCUSSION

In general, it is possible to infer that there is no rationality behind fluorosis trends in Brazil. Small variations may be acceptable, bearing in mind that strategies for controlling fluoride in the water may vary between state capitals.

However, these data may indicate, fundamentally, the validity of the data themselves, in other words, an epidemic prevalence (61%) in Palmas is inconceivable. In Belo Horizonte there seemed to be logic in terms of the trend, but the values are very high in both years, even for a city which adds fluoride to the water. The

Table 2. Standard errors and confidence intervals for prevalence estimates based on different sample sizes for the design effect of 2.

N	Estimated prevalence (%)									
	5		10		25		40		50	
	S.E.	95%CI	S.E.	95%CI	S.E.	95%CI	S.E.	95%CI	S.E.	95%CI
250	1.95	1.2;8.8	2.68	4.7;15.3	3.87	17.4;32.6	4.38	31.4;48.6	4.47	41.2;58.8
500	1.38	2.3;7.7	1.90	6.3;13.7	2.74	19.6;30.4	3.10	33.9;46.1	3.16	43.8;56.2
750	1.13	2.8;7.2	1.55	7.0;13.0	2.24	20.6;29.4	2.53	35.0;45.0	2.58	44.9;55.1
1,000	0.97	3.1;6.9	1.34	7.4;12.6	1.94	21.2;28.8	2.19	35.7;44.3	2.24	45.6;54.4
1,500	0.80	3.4;6.6	1.10	7.9;12.1	1.58	21.9;28.1	1.79	36.5;43.5	1.83	46.4;53.6
2,000	0.44	4.1;5.0	0.95	8.1;11.9	1.37	22.3;27.7	1.55	37.0;43.0	1.58	46.9;53.1

Source: Adapted from the United Nations, 2005 (p.63).

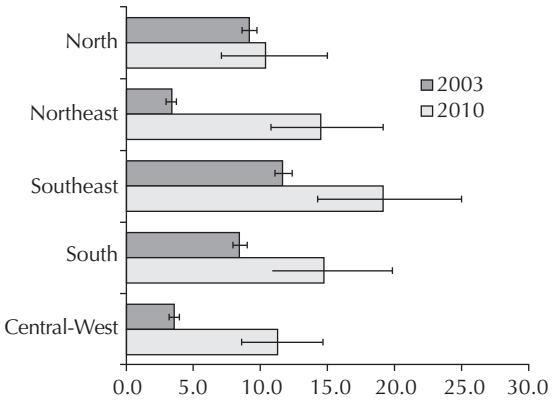

Figure 2. Prevalence of fluorosis according to region and year. SBBrasil 2003 and SBBrasil 2010.

same is true, to a lesser degree, of São Paulo. The case of Salvador is emblematic, with an increase from 7.6% in 2003 (an acceptable value for a city which adds fluoride to the water) to 44.3% in 2010. Finally, there is no explanation for the case of Florianópolis in which, although the value for 2010 was not that high, it represented a 15 fold increase. In these municipalities there are no records of significant alterations in the tap water or of increases in the sources of fluoride which justify such marked changes.

The definition of fluorosis and the methodological considerations necessary for its clinical and epidemiological diagnosis are significant, given the subjectivity of the classification. Examinations for dental fluorosis may contain more variations than those carried out for other oral health conditions.[21] The difficulties in diagnosing and characterizing milder cases of fluorosis may be caused by the presence of opacity in the enamel not due to fluoride. It is possible that there is confusion in the differential diagnosis between milder forms of fluorosis and opacities not caused by fluoride.[11]

Moreover, the diversity of the indexes proposed to measure fluorosis, combined with the need for rigorous training for the examiners and the lack of a standardized and less subjective method have been highlighted as the causes of difficulties in comparing studies on the evaluating trends in prevalence,[26] and is a problem for the reliability and consistency of the data.

Various studies measuring fluorosis have been carried out using the Dean index, or variations of the Dean and other indexes,[3,13,17,18,22] showing various discrepancies and limitations to the use.[21]

New research has been developed out in order to establish new methodologies and protocols in epidemiological surveys,[23] aiming to improve diagnosis using photographs. Some studies[6,18] conclude that the method using photographs is more reproducible and reliable than clinical examinations and can be used to diagnose dental fluorosis.

Among the limitations of this study, the difficulty of working with two databases constituted from different sample designs and different training procedures stand out. The teams for the SBBrasil 2010 received training using slides with photographs of various stages of fluorosis, so-called training in lux,[d] whereas in the SBBrasil 2003 the training followed the traditional method. However, the intra and inter-examiner concordance values for the kappa statistic were not divulged in either situation.

Thus, depending on the training process and the characteristics of the examiner, it is possible that the examiners overestimated (Palmas in 2003 and Belo Horizonte in 2010) and underestimated (São Luís) fluorosis. This seemed to occur even in different years (in 2003 and in 2010), as in the example of what happened in Palmas (prevalence dropped to 11% form 60%) and in Florianópolis (where there was an increase from 1% to 16.4%).

The discrepancies between the SBBrasil 2003 and the SBBrasil 2010 data are even more pronounced when independent studies published in the literature are introduced for comparison. For example, Aracaju, with a prevalence of 7.8% in 2003 and 25.4% in 2010. In an independent study[4] in Aracaju of 196 schoolchildren aged between five and 15 who underwent an oral examination using the Dean index found an 8.16% prevalence of dental fluorosis.

Another important aspect concerns the estimative power, a fundamental question in establishing the statistical significance of the differences (between years, regions and domains, for example). In addition, the confidence interval of the prevalence is a population estimate and indicates the precision of this value in estimating the true parameter.

The interval estimate is calculated considering standard error and, therefore, is a function of the sample size itself. Thus, low values of prevalence would have the same standard error for a specific sample size so that the effect is proportionally greater.[25] The lower the prevalence value the greater the proportional interval for a given sample.

In the SBBrasil 2010 the sample of 12-year-olds considered an ideal coefficient of variation (ration between standard error and prevalence) to be below 15%. This means that, for an expected sample of 250 children, a reasonable power of precision can only be observed for

[d] Ministério da Saúde (BR), Secretaria de Atenção à Saúde, Departamento de Atenção Básica, Coordenação Nacional de Saúde Bucal. Projeto SB Brasil 2010 – Pesquisa Nacional de Saúde Bucal: manual de calibração de examinadores. Brasília (DF); 2009.

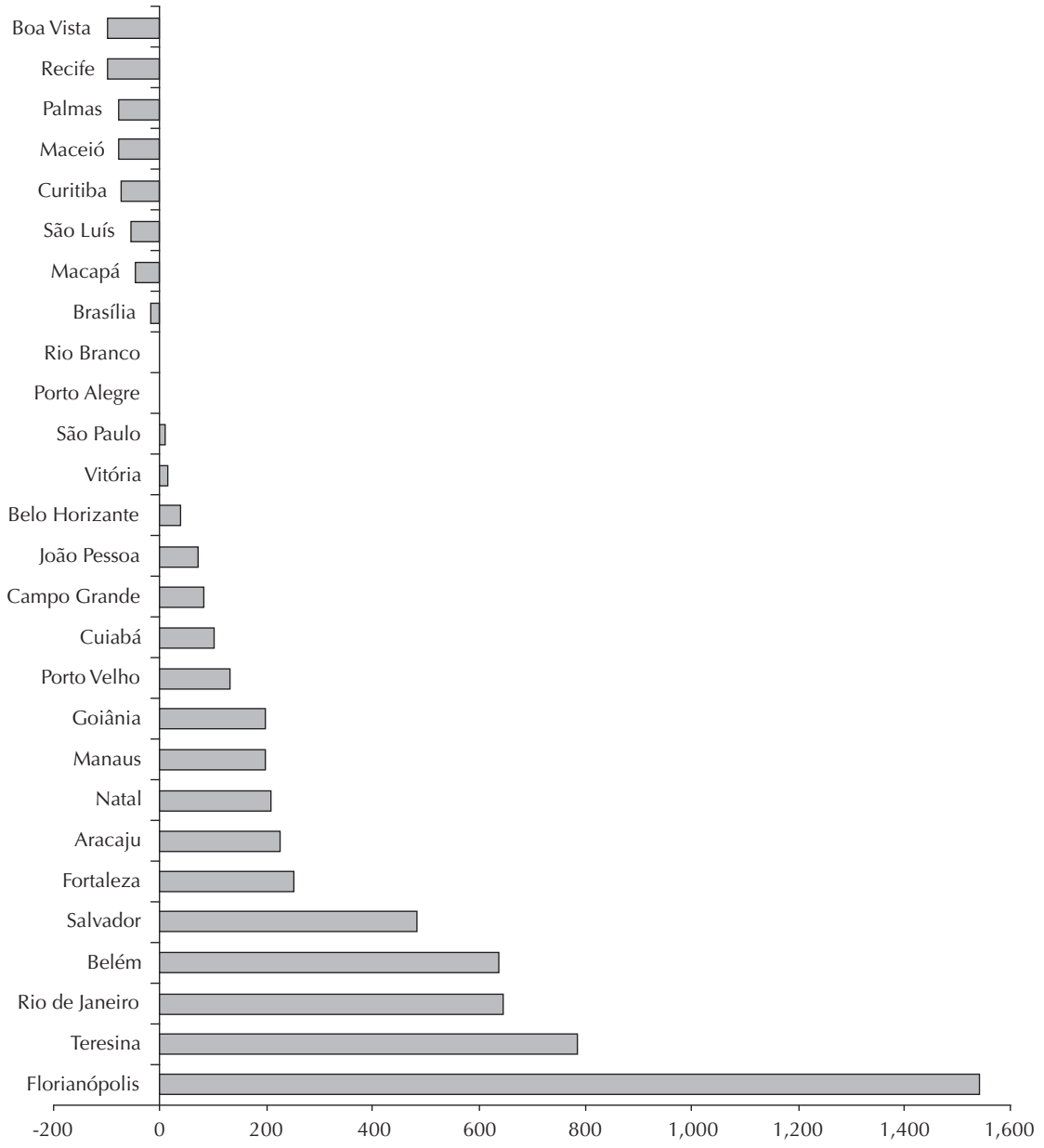

Figure 3. Percentage differences in the prevalence of fluorosis between 2003 and 2010. SBBrasil 2003 and SBBrasil 2010.

rates of prevalence above 20%. From the point of view of methodological choice, this is because of the fact that the sample size considered dental caries as the reference health problem.[e] Although other health problems were assessed in the SBBrasil 2010, a considerable number of them had higher rates of prevalence so that this sample size proved feasible in generating good estimates for the majority of situations.

In the case of fluorosis, a health problem with a low prevalence, taking only the simple value (presence of fluorosis without considering levels of severity) will generate estimates with a high coefficient of variation; in other words, low precision. If levels of severity were included, precision would decrease still further, especially when considering the prevalence of severe and very severe stages. In general, therefore, the power to establish differences between the study domains, with this sample size, is fairly limited.

This also occurs due to the fact that the confidence intervals are affected by design effect when the estimate is obtained based on a complex sample design. As can be seen in the formula (1), the standard error is calculated including the square of the design effect (d). In the SBBrasil 2010, the design effect was estimated to be

[e] Ministério da Saúde (BR), Secretaria de Atenção à Saúde. Projeto SB Brasil 2010 - Pesquisa Nacional de Saúde Bucal. Brasília (DF); 2009.

2.0; however, depending on how the field research was carried out, this value was above that predicted in various state capitals. Allied to this, in some state capitals, the sample size of 250 was not reached, increasing the interval yet further and worsening the estimate. Thus, the formula shows that a combination of low prevalence, small sample size and high design effect produces high standard errors and, consequently, poor accuracy. For example, in the municipality of João Pessoa, with a sample of 139 children, there was an 8% prevalence with an interval of 2.4% to 23.8%, in other words, information which is next to useless.

Thus, the sample size for this health problem, estimated at 1,500 12-year-olds, leads to a discussion regarding the viability and feasibility of carrying out population studies for this health problem. A sample of 1,500 12-year-old children to be visited in their homes, if the same protocol was used as in the SBBrasil 2010, would call for approximately 19 thousand households to be visited (estimating a 2% proportion of the population of 12-year-old children and a mean of four individuals per household). Visiting 19 thousand households means including more than 60 census tracts and carrying out research in all of the residences, without sampling fractions.

Obtaining estimates with poor precision, as well as invalidating the comparative analyses (as exemplified in the case of the state capitals), also makes it impossible to carry out other studies which aim to identify associated factors based on ecological type designs, as the points estimate is imprecise.

Another possibility would be to compare data from previous years, such as 2003, in which the study was carried out based on the same criteria. However, there is the inherent problem of inconsistency in the data; although the data are considered reliable from the point of view of the validity of the index, it would be impossible to make a comparison as different models of analysis were used in the two surveys. The confidence intervals were calculated in different ways, in 2003 as if it were a simple causal sample and in 2010 considering weighting and cluster effects. This means that the 2003 intervals are artificially lower (proportionally) than those of 2010, as, in this case, the intervals were corrected by weighting "lengthening" the values. Thus, in practice, it is not possible to compare the results for the intervals, nor to carry out statistical tests.

To conclude, it is not possible to analyze trends in dental fluorosis in Brazil using the data available from the 2003 and 2010 studies, and these data are merely exploratory indicators of the prevalence of fluorosis. In general, the analysis conducted in this article indicates that discussion is needed concerning the technical and economic viability of investigating dental fluorosis in population based surveys for the country as a whole. This type of research should be carried out using local epidemiological studies with appropriate sampling plans.

Thus, it should be emphasized that this article does not aim to discourage epidemiological studies into dental fluorosis, nor to invalidate the data produced by the SBBrasil 2003 and SBBrasil 2010. The data have been essential in reinforcing the need for such studies to have specific and directed sampling plans in order to serve as basic guidance to strategies for controlling fluoridation of tap water, as well as monitoring the occurrence of episodes of endemic fluorosis.

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