

Dental erosion in 12-year-old schoolchildren: a cross-sectional study in Southern Brazil

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Summary. *Objective.* The aim of this study was to assess the prevalence and severity of dental erosion among 12-year-old schoolchildren in Joaçaba, southern Brazil, and to compare prevalence between boys and girls, and between public and private school students.

Methods. A cross-sectional study was carried out involving all of the municipality's 499, 12-year-old schoolchildren. The dental erosion index proposed by O'Sullivan was used for the four maxillary incisors. Data analysis included descriptive statistics, location, distribution, and extension of affected area and severity of dental erosion.

Results. The prevalence of dental erosion was 13.0% (95% confidence interval = 9.0–17.0). There was no statistically significant difference in prevalence between boys and girls, but prevalence was higher in private schools (21.1%) than in public schools (9.7%) ($P < 0.001$). Labial surfaces were less often affected than palatal surfaces. Enamel loss was the most prevalent type of dental erosion (4.86 of 100 incisors). Sixty-three per cent of affected teeth showed more than a half of their surface affected.

Conclusion. The prevalence of dental erosion in 12-year-old schoolchildren living in a small city in southern Brazil appears to be lower than that seen in most of epidemiological studies carried out in different parts of the world. Further longitudinal studies should be conducted in Brazil in order to measure the incidence of dental erosion and its impact on children's quality of life.

Introduction

Over recent decades, with the decline in both the prevalence and severity of dental caries in children from most developed countries [1], as well as in Brazil [2,3], has come an increasing interest in other dental disorders including dental erosion. Renewed interest in the study of tooth wear, and especially of erosion, began in the 1980s [4].

Dental erosion is defined as the acid dissolution of the tooth surface by chemical attack not involving bacteria [5]. The aetiological factors of dental erosion in children and adolescents include: acidic beverages, such as citric fruit juices, soft drinks and carbonated beverages; vomiting and gastroesophageal reflux; and frequent swimming in heavily chlorinated water. Acids present in the work environment, bulimia, heavy alcohol consumption and spicy food consumption have also been mentioned as major risk factors among adults [6].

Much research in this area has been focused on clinical aspects through case reports, or *in vivo*

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|--|--|
| Site of erosion on each tooth | |
| Code A | Labial or labial only |
| Code B | Lingual or palatal only |
| Code C | Occlusal or incisal only |
| Code D | Labial and incisal/occlusal |
| Code E | Lingual and incisal/occlusal |
| Code F | Multi-surface |
| Grade of severity (worst score for any individual tooth recorded) | |
| Code 0 | Normal enamel |
| Code 1 | Matte appearance of the enamel surface with no loss of contour |
| Code 2 | Loss of enamel only |
| Code 3 | Loss on enamel with exposure of dentin (ADJ visible) |
| Code 4 | Loss of enamel and dentin beyond ADJ |
| Code 5 | Loss of enamel and dentine with exposure of pulp |
| Code 9 | Unable to assess (e.g. tooth crowned or large restoration) |
| Area of surface affected by erosion | |
| Code – | Less than half of the surface affected |
| Code + | More than half of the surface affected |

Source: O'Sullivan, 2000.

Fig. 1. O'Sullivan index for the measurement of dental erosion [12].

intraoral pH measurements. There have also been studies involving superficial microhardness determinations of enamel and dentin, and *in vitro* and animal investigations [7,8]

Most epidemiological studies addressing dental erosion have been conducted in developed countries, such as the UK [4,9–11]. In contrast, Medline and Brazilian Library of Dentistry (BBO) searches have failed to show data on dental erosion in population-based studies in Brazil. Consequently, the prevalence and severity of dental erosion in Brazil are currently unknown.

The aim of this study was to assess the prevalence and severity of dental erosion in 12-year-old schoolchildren from Joaçaba, Southern Brazil, and in addition, to compare the prevalence of dental erosion in boys and girls, and between schoolchildren enrolled in public and private schools.

Subjects and methods

A cross-sectional study was carried out in Joaçaba in the western region of the state of Santa Catarina, Southern Brazil. All 12-year-old schoolchildren ($n = 499$) of both sexes attending public and private primary schools in the city in 2001 were invited to participate in the survey. A total of 391 children were examined in this cross-sectional survey.

The study was formally supported by the Brazilian Dental Association – Santa Catarina (*Associação Brasileira de Odontologia – Santa Catarina*) and by

Joaçaba Municipal Health Authorities. A written consent was required from each parent or guardian. A letter was sent to the parents stating the objectives and importance of the study, asking for their participation, and assuring them that children who opted not to participate in the study would not be discriminated against in any way. Local authorities such as health and education councils were also contacted, and provided necessary information and authorization.

One examiner (M.F.A.) carried out clinical examinations supported by a scribe. Before commencing, M.F.A. was trained by an experienced dental epidemiologist (K.G.P.) who was regarded as the gold standard. A range of different levels of dental erosion was used in the calibration exercise, which was based on diagnosis of photographic images. Reliability was assessed through the Kappa test.

The dental erosion index proposed by O'Sullivan [12] was adopted and was adjusted for use in the four upper incisors (Fig. 1). The partial record using groups of index teeth was used to make the index more applicable for larger-scale population surveys, where there is the need to measure several different disease processes, or a very large sample [13]. Children were clinically examined at their schools under standard artificial illumination using plane mouth mirrors and sterilized gauze to remove gross debris. The four upper incisors were examined. Each examination for erosion lasted 30 s on average. Children with fractured teeth, hypoplasia, extensive restorations or who were wearing orthodontics appliances were excluded.

The sociodemographic data collected included sex and type of school. 'Type of school' refers to the differentiation of students enrolled in public and private schools. Since public schools do not collect tuition fees, it was assumed, as in previous studies, that children attending private schools in the Brazilian context would be of higher socioeconomic status than those enrolled in public schools [14].

Intra-examiner reliability during field work was checked with duplicate examinations of every tenth subject. The Kappa statistic was calculated on a tooth-by-tooth basis. The Epi info 6.04 computer program was used, and data analysis included descriptive statistics, including distribution of erosion, and its extent and severity. Differences in the prevalence of dental erosion according to gender and type of school were tested in terms of frequencies using the chi-square test. The level of significance was set at $P < 0.05$.

Results

Of the 499, 12-year-olds in the municipality, a total of 391 children were examined. Thus, the response rate obtained was 78.3%. The main reasons for nonresponse were absence on the day of the exam and lack of parental consent. Differences between school types in these losses were not statistically significant ($P = 0.20$). Of the 391 children included, 203 (51.9%) were boys and 188 (48.1%) were girls; 277 (70.8%) were from public schools and 114 (29.2%) from private schools.

Kappa values calculated for intraexaminer variability were all higher than 0.78.

The prevalence of any dental erosion was 13.0% [95% confidence interval (95% CI) = 9.0–17.0], with no significant difference between sexes (Table 1). Table 1 also shows that the prevalence was significantly

Table 1. Prevalence of any dental erosion in 12-year-old schoolchildren according to sex and type of school in Joaçaba, Brazil, in 2001 (chi-square test).

| Variable | Dental erosion | | Total [n (%)] | P-value |
|-----------------------|----------------|------------|---------------|---------|
| | Yes [n (%)] | No [n (%)] | | |
| <i>Sex</i> | | | | |
| Male | 22 (10.8) | 181 (89.2) | 203 (100.0) | 0.232 |
| Female | 29 (15.4) | 159 (84.6) | 188 (100.0) | |
| Total | 51 (13.0) | 340 (87.0) | 391 (100.0) | |
| <i>Type of school</i> | | | | |
| Private | 24 (21.1) | 90 (78.9) | 114 (100.0) | 0.004 |
| Public | 27 (9.7) | 250 (90.3) | 277 (100.0) | |
| Total | 51 (13.0) | 340 (87.0) | 391 (100.0) | |

Table 2. Number (%) of tooth surfaces affected by dental erosion in 12-year-old schoolchildren in Joaçaba, Brazil, in 2001.

| Affected surface | Number | Percentage |
|---------------------|--------|------------|
| Labial only | 47 | 31.3% |
| Palatal only | 37 | 24.7% |
| Incisal only | 11 | 7.3% |
| Labial and incisal | 24 | 16.0% |
| Palatal and incisal | 21 | 14.0% |
| Multi-surface | 10 | 6.7% |
| Total | 150 | 100.0% |

Table 3. Severity of dental erosion in 12-year-old schoolchildren in Joaçaba, Brazil, in 2001, according to the number of surfaces per 100 examined incisors ($n = 1564$ incisors).

| Location | Number | Relative frequency per 100 incisors |
|---|--------|-------------------------------------|
| Matt appearance of the enamel surface with no loss of contour | 76 | 4.86 |
| Loss of enamel only | 69 | 4.41 |
| Loss on enamel with exposure of dentin | 5 | 0.32 |
| Total | 150 | 9.59 |

Table 4. Area of the surface affected by dental erosion in 12-year-old schoolchildren in Joaçaba, Brazil, in 2001, according to the number of affected surfaces per 100 examined incisors ($n = 1564$ incisors).

| Area affected | Number | Relative frequency per 100 incisors |
|--|--------|-------------------------------------|
| Less than half of the surface affected | 98 | 6.27 |
| More than half of the surface affected | 52 | 3.32 |
| Total | 150 | 9.59 |

antly different between school types ($P = 0.004$), i.e. it was higher in private schools (21.1%) than in public schools (9.7%).

Of the total surfaces affected ($n = 150$), 31.3% and 24.7% were identified in labial and on palatal surfaces, respectively (Table 2). Concerning the severity of dental erosion, enamel loss without the loss of tooth surface characteristics was observed in most cases (4.86 of 100 incisors), followed by the enamel loss with loss of tooth contour (4.41 of 100 incisors) (Table 3). In 62.6% of the affected teeth, more than half of the tooth's surface was affected (Table 4).

Discussion

Both the high response rate and the high intraexaminer agreement observed suggest that the

internal validity of this study was good. In addition, since the attendance rate among schoolchildren in Joaçaba is very high, reaching more than 90% [15], it is reasonable to generalize the results for 12-year-old children as a whole in this municipality. The use of upper incisors when investigating dental erosion in 12-year-old children is appropriate since, at this age, these teeth have been exposed in the mouth for a considerable length of time when compared to other teeth. Thus, incisors are more exposed to possible intrinsic and extrinsic aetiological factors which may cause dental erosion. Other studies have included molars since these teeth have also been shown to be susceptible to erosion. However, confining examination to incisors was thought to make the index easier to use in large studies.

It is difficult to distinguish the three main types of tooth wear, i.e. erosion, attrition and abrasion, and it is likely that all three processes may have been included in some of the cases seen in this study. The use of a smaller number of index teeth may make it easier to achieve good validity. According to Steele and Walls [13], it is difficult to train examiners to measure any one of these conditions to a high level of agreement, let alone all of them. Moreover, the full assessment of all of these conditions is very time-consuming.

A 13% prevalence of dental erosion was found among 12-year-old schoolchildren (95% CI = 9.0%–17.0%). This prevalence is similar to the results of a study conducted by Ganss *et al.* [16], who found that 11.6% of children with permanent teeth had at least one tooth with some level of erosion. The above authors had used pre-orthodontic study models from 1000 individuals between 1977 and 1999 in Germany. On the other hand, the prevalence found in this study was lower than the majority of findings reported by several other authors in different countries. In the UK Children's Dental Health Survey of 1993, 32% of 14-year-old children showed some degree of erosion [10]. Milosevic *et al.* [17], reported that 30% of 14-year-old children exhibited exposed dentin because of erosion in Liverpool, UK. Pronounced dental erosion was observed in 26% of a sample of 12–14-year-old in Riyadh, Saudi Arabia [18]. A very high prevalence of dental erosion was also observed in the USA (41%) among children aged 11–13 years [19]. Another study, conducted in Birmingham, UK, found a 48% prevalence among 14-year-old schoolchildren [20]. A higher prevalence than that of this study was also reported for a

random sample of 12-year-old schoolchildren living in Leicestershire and Rutland, UK, where 56.3% of subjects had some level of dental erosion [21].

The differences observed between the results of this study and those of other investigations may be explained by several factors. First, the different criteria used in the various studies could be at least partly the reason for this discrepancy. The Tooth Wear Index (TWI) [22] is the most extensively adopted index to measure dental erosion, but it can overestimate the prevalence of this condition because it is not specific for dental erosion, and consequently, measures different types of tooth wear. Secondly, it is difficult to compare the results of prevalence studies when different teeth are included in the measurement method. Standardization of the indices and the teeth examined would facilitate such comparisons. Finally, the permanent dentition analysed in different studies shows erosion at ages ranging from 12 to 14 years, which may also influence the results through differences in time of exposure to risk factors.

The predominance of erosion on the labial surface seen in this study is in agreement with data reported by Williams *et al.* [11] and also by Al-Majed *et al.* [18].

In this study, the child's school was regarded as a proxy for social class, with those attending private schools being from families of higher socioeconomic status.

When the influence of socioeconomic status on the prevalence of dental erosion is reviewed, previous studies have shown contradictory results. Millward *et al.* [23] found a higher prevalence of erosion among children of higher socioeconomic status than among underprivileged children in Birmingham, UK, although the children included were of younger age than those in the current study. Williams *et al.* [11] reported palatal erosion as more prevalent in more affluent areas compared to deprived areas in two inner-city boroughs of London, UK. In contrast, Al-Dlaigan *et al.* [20] reported a significantly higher prevalence of erosion in teenagers of the lowest socioeconomic group in Birmingham, UK, and Milosevic *et al.* [17] also found a slight positive association between tooth wear and the level of social deprivation (according to the electoral ward where the school was located) in Liverpool, UK. Erosion experience was also found to be associated with social deprivation in 12-year-old schoolchildren, in Leicestershire, UK [21].

One hypothesis that could explain the findings of this study is related to dietary habits, especially the

consumption of acidic beverages, such as soft drinks, carbonated beverages and yoghurt. These risk factors are more prevalent among higher-income social groups, such as children enrolled in private schools, in both international [24] and Brazilian food consumption surveys [25,26], but this pattern may not be true in all countries. For example, it may be that the consumption of erosive drinks in the UK is greater among those of lower socioeconomic status.

In this study, there was no difference in the prevalence of dental erosion between males and females, which is in agreement with a study carried out by Deery *et al.* [19] in the UK and the USA. On the other hand, Milosevic *et al.* [17] found a significantly higher prevalence of exposed dentin in males than in females, mainly affecting the incisal edge. The same result was obtained by Al Dlaigan *et al.* [20] in Birmingham, UK, where more males had buccal/labial and lingual/palatal tooth surface erosion than females, and also by Dugmore *et al.* [21] in Leicestershire, UK. The absence of significant differences in the prevalence of dental erosion between boys and girls in this study may perhaps be explained by a similar patterns of exposure to risk factors in this population.

The majority of teeth affected by dental erosion had less than half of the surface affected. One hypothesis is that these individuals may have been exposed to dental erosion risk factors at low levels, or for a relatively short time. Longitudinal studies should provide evidence to correctly explain this finding.

It may be concluded that the prevalence of dental erosion in 12-year-old schoolchildren living in a small city in Southern Brazil is lower than has been reported in most epidemiological studies carried out in different countries. The current results suggest the need for further research on the prevalence and incidence and progression of dental erosion in Brazil.

What this paper adds

- This paper demonstrates the prevalence of erosion in a sample of 12-year-old children in Joaçaba, Southern Brazil, to be 13%, a value lower than that reported in the UK.
- The prevalence was higher amongst children attending private schools than in those from publicly funded schools.

Why this paper is important for paediatric dentists

- This paper adds to the understanding of erosion at an international level and demonstrates that the issue is widely prevalent.

Therefore the authors recommend further longitudinal epidemiological studies in order to measure the incidence of dental erosion as well as to assess its impact, if any, on children's quality of life.

Résumé. *Objectif.* L'objectif de cette étude a été d'évaluer la prévalence et la sévérité de l'érosion dentaire chez les enfants de 12 ans, scolarisés, de Joaçaba, Sud du Brésil, et de comparer la prévalence entre garçons et filles et entre enfants des écoles publiques et privées.

Méthodes. Une étude transversale a été menée chez 499 enfants de 12 ans scolarisés. L'indice d'érosion dentaire proposé par O'Sullivan a été utilisé pour les 4 incisives maxillaires. L'analyse des données a inclus des statistiques descriptives, la distribution des sites, l'étendue des zones affectées et la sévérité de l'érosion dentaire.

Résultats. La prévalence de l'érosion dentaire était de 13,0% [95% IC 9,0%–17,0%]. Il n'y avait pas de différence statistiquement significative entre garçons et filles, mais la prévalence était plus importante dans les écoles privées (21,1%) que publiques (9,7%) ($p < 0,001$). Les surfaces vestibulaires étaient moins souvent atteintes que celles palatines. La perte d'émail était le type le plus fréquent (4,86/100 incisives). Soixante-trois pour cent des dents atteintes avaient plus de la moitié de leur surface affectée.

Conclusion. La prévalence de l'érosion dentaire chez les enfants de 12 ans scolarisés d'une petite ville du Sud Brésil semble plus faible que celle rencontrée dans la plupart des études épidémiologiques menées dans différentes parties du monde. Des études longitudinales devraient être menées au Brésil afin de mesurer l'incidence de l'érosion dentaire et son impact sur la qualité de vie des enfants.

Zusammenfassung. *Ziel.* Ziel dieser Studie war es, Prävalenz und Ausprägung von Erosionen bei 12 jährigen Schulkindern in Joaçaba, Südbasilien, herauszufinden und zwischen Jungen und Mädchen sowie zwischen öffentlichen und privaten Schulen zu vergleichen.

Methoden. Eine Querschnittstudie wurde unter Berücksichtigung aller 499 zwölfjährigen Schulkinder der Gemeinde durchgeführt. Der Zahnerosionsindex nach O'Sullivan wurde zur Beurteilung der vier Oberkiefer Schneidezähne eingesetzt. Die Datenanalyse beinhaltete deskriptive Statistik hinsichtlich lokaler Verteilung, der Ausdehnung der betroffenen Regionen sowie der Schweregrade.

Resultados. La prevalencia de la erosión dental fue del 13,0% [95% CI 9,0%–17,0%]). No hubo diferencias estadísticamente significativas en la prevalencia entre niños y niñas, pero la prevalencia fue más alta en escuelas privadas (21,1%) que en escuelas públicas (9,7%) ($p < 0,001$). Las superficies labiales estaban afectadas con menos frecuencia que las superficies palatinas. La pérdida de esmalte fue el tipo más prevalente de erosión dental (4,86/100 incisivos). El 63% de los dientes afectados mostró más de la mitad de una superficie afectada.

Conclusion. La prevalencia de erosión dental en niños escolares de 12 años que viven en una ciudad pequeña en el Sur de Brasil parece ser menor que lo visto en la mayoría de estudios epidemiológicos realizados en diferentes partes del mundo. Deberían hacerse en Brasil más estudios longitudinales para medir la incidencia de la erosión dental y su impacto en la calidad de vida de los niños.

Resumen. Objetivo. El objetivo de este estudio fue valorar la prevalencia y severidad de la erosión dental en niños escolares de 12 años de Joaçaba, Sur de Brasil y comparar la prevalencia entre niños y niñas y entre estudiantes de escuela pública y privada. **Métodos.** Se realizó un estudio transversal implicando a los 499 niños escolares de 12 años del municipio. El índice de erosión dental propuesto por O'Sullivan se usó para los cuatro incisivos superiores. El análisis de los datos incluyó estadísticas descriptivas, distribución de la localización, extensión del área afectada y severidad de la erosión dental.

Resultados. La prevalencia de la erosión dental fue del 13,0% [95% CI 9,0%–17,0%]). No hubo diferencias estadísticamente significativas en la prevalencia entre niños y niñas, pero la prevalencia fue más alta en escuelas privadas (21,1%) que en escuelas públicas (9,7%) ($p < 0,001$). Las superficies labiales estaban afectadas con menos frecuencia que las superficies palatinas. La pérdida de esmalte fue el tipo más prevalente de erosión dental (4,86/100 incisivos). El 63% de los dientes afectados mostró más de la mitad de una superficie afectada.

Conclusión. La prevalencia de erosión dental en niños escolares de 12 años que viven en una ciudad pequeña en el Sur de Brasil parece ser menor que lo visto en la mayoría de estudios epidemiológicos realizados en diferentes partes del mundo. Deberían hacerse en Brasil más estudios longitudinales para medir la incidencia de la erosión dental y su impacto en la calidad de vida de los niños.

References

- Petersson HG, Bratthall D. The caries decline: a review of reviews. *European Journal of Oral Science* 1996; **104**: 436–443.
- Souza SMD. CPO-D brasileiro aos 12 anos tem redução de 53·22%. *Jornal da ABO Nacional* 1996; **8**.
- Roncalli AG. *Levantamento epidemiológico em saúde bucal – 1ª etapa – Cárie Dental, 1996. Relatório Paralelo*. [WWW document.] URL <http://www.angelonline.cjb.net>
- Nunn J, Shaw L, Smith A. Tooth wear: dental erosion. *British Dental Journal* 1996; **180**: 349–352.
- Pindborg JJ. *Pathology of Dental Hard Tissues*. Copenhagen: Munksgaard, 1970.
- Shaw L, Smith AJ. Dental erosion – the problem and some practical solutions. *British Dental Journal* 1998; **186**: 115–118.
- Fushida CE, Cury JA. Estudo in situ do efeito da frequência de ingestão de Coca-Cola na erosão do esmalte dentina e reversão pela saliva. *Revista de Odontologia da Universidade de São Paulo* 1999; **13**: 127–134.
- West NX, Hughes JA, Parker DM, Moohan M, Addy M. Development of low erosive carbonated fruit drinks 2. Evaluation of an experimental carbonated blackcurrant drink compared to a conventional carbonated drink. *Journal of Dentistry* 2003; **31**: 361–365.
- Barlett DW, Coward PY, Nikkah C, Wilson RF. The prevalence of tooth wear in a cluster sample of adolescent schoolchildren and its relationship with potential explanatory factors. *British Dental Journal* 1998; **184**: 125–129.
- O'Brien M. *Children's Dental Health in the United Kingdom 1993 Office of Population Censuses and Surveys*. London: Her Majesty's Stationary Office, 1994.
- Williams D, Croucher R, Marcenes W, O'Farrel M. The prevalence of dental erosion in the maxillary incisors of 14-year-old schoolchildren living in Tower Hamlets and Hackney, London, UK. *International Dental Journal* 1999; **49**: 211–216.
- O'Sullivan EA. A new index for measurement of erosion in children. *European Journal of Paediatric Dentistry* 2000; **2**: 69–74.
- Steele JG, Walls AWG. Using practical recording to assess tooth wear in older adults. *Community Dentistry and Oral Epidemiology* 2000; **28**: 18–25.
- Antunes JLF, Frazão P, Narvai PC, Bispo CM, Pegoretti T. Spatial analysis to identify differentials in dental needs by area-based measures. *Community Dentistry and Oral Epidemiology* 2002; **30**: 133–142.
- United Nation Children's Fund (UNICEF). *Situação da criança brasileira 2001*. Brasília: UNICEF-Brasil, 2001.
- Ganss C, Klimek J, Giese K. Dental erosion in children and adolescents – a cross-sectional and longitudinal investigation using study models. *Community Dentistry and Oral Epidemiology* 2001; **29**: 264–271.
- Milosevic A, Young PJ, Lennon MA. The prevalence of tooth wear in 14-year-old school children in Liverpool. *Community Dental Health* 1994; **11**: 83–86.
- Al-Majed I, Maguire A, Murray JJ. Risk factors for dental erosion in 5–6 year old and 12–14 year old boys in Saudi Arabia. *Community Dentistry and Oral Epidemiology* 2002; **30**: 38–46.
- Deery C, Wagner ML, Longbottom C, Simon A, Nugent ZJ. The prevalence of dental erosion in a United States and a United Kingdom sample of adolescents. *Pediatric Dentistry* 2000; **22**: 505–510.

- 20 Al-Dlaigan YH, Shaw L, Smith A. Dental erosion in a group of British 14-year-old school children. Part I. Prevalence and influence of differing socioeconomic backgrounds. *British Dental Journal* 2001; **190**: 145–149.
- 21 Dugmore CR, Rock WP. The progression of tooth erosion in a cohort of adolescents of mixed ethnicity. *International Journal of Paediatric Dentistry* 2003; **13**: 295–303.
- 22 Smith BGN, Knight JK. An index for measuring the wear of teeth. *British Dental Journal* 1984; **156**: 435–438.
- 23 Millward A, Shaw L, Smith A. Dental erosion in four-year-old children from differing socioeconomic backgrounds. *Journal of Dentistry for Children* 1994; **61**: 263–266.
- 24 Hupkens CLH, Knibbe RA, Van Otterloo AH, Drop MJ. Class difference in the food rules mothers impose on their children: a cross-national study. *Social Science and Medicine* 1998; **47**: 1331–1339.
- 25 de Aquino RC, Philippi ST. Association of children's consumption of processed foods and family income in the city of Sao Paulo. *Revista de Saúde Pública* 2002; **36**: 655–660. [In Portuguese.]
- 26 Monteiro CA, Mondini L, Costa RBL. Changes in composition and appropriate nutrition of family diet in the metropolitan areas of Brazil (1988–1996). *Revista de Saúde Pública* 2000; **34**: 251–258. [In Portuguese.]