

Dietary calcium intake in Brazilian preschoolers and schoolchildren: review of the literature

Ingesta de cálcio dietético em pré-escolares e escolares brasileiros: revisão da literatura

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ABSTRACT

Objective: The objective of this study was to map and synthesize evidence on the adequacy of dietary calcium intake and dairy products in Brazilian preschoolers and schoolchildren.

Data source: Evidence searches were performed in the MEDLINE (via PubMed) and Latin American and Caribbean Health Sciences Literature (LILACS; via BVS) databases, with no restriction on date or language of publication. Experimental or observational studies that evaluated healthy Brazilian children between 2 and 12 incomplete years old were included.

Data synthesis: A total of 18 studies were included. Seven of 11 studies of 11 studies (63.6%) identified mean values of dietary calcium intake below the age recommendation, especially in schoolchildren, with the progression of the age group. Among preschoolers, studies with direct weighing of food showed higher mean values of dietary calcium ingested compared to those with dietary recall. Children attending public daycare centers on a part-time basis tended to have inadequate calcium intake. The consumption of milk and dairy products was lower among older children, especially schoolchildren.

Conclusions: Inadequate dietary calcium intake seems to be prevalent in Brazil during childhood, especially among schoolchildren. Therefore, the evaluation of milk and dairy products intake must be considered in order to design appropriate corrective actions.

Keywords: Calcium, dietary; Child; Brazil; Dairy products.

RESUMO

Objetivo: Mapear e sintetizar as evidências sobre a adequação do consumo de cálcio dietético e laticínios em crianças brasileiras pré-escolares e escolares.

Fontes de dados: As buscas pelas evidências foram realizadas nas bases de dados *Medical Literature Analysis and Retrieval System Online* (Medline, via PubMed) e Literatura Latino-Americana e do Caribe em Ciências da Saúde (Lilacs, via Biblioteca Virtual em Saúde — BVS), sem restrição de data ou idioma de publicação. Foram incluídos estudos experimentais ou observacionais que avaliaram crianças brasileiras saudáveis com idade entre dois e 12 anos incompletos.

Síntese dos dados: Foram incluídos 18 estudos. Sete de 11 estudos (63,6%) identificaram valores médios da ingestão de cálcio dietético abaixo do recomendado para a idade, principalmente em escolares, com a progressão da faixa etária. Entre os pré-escolares, estudos com pesagem direta dos alimentos apresentaram maiores valores médios de cálcio dietético ingerido comparados aos obtidos com recordatório alimentar. Crianças frequentadoras de creches públicas em regime de meio período tiveram a maior inadequação da ingestão de cálcio. A ingestão de leite e derivados foi menor entre as crianças com idade mais avançada, principalmente em escolares.

Conclusões: A inadequação da ingestão de cálcio dietético parece ser prevalente no Brasil, principalmente em escolares. Sendo assim, a avaliação da ingestão de leite e derivados é um ponto a ser observado para a realização de ações corretivas nessa faixa etária.

Palavras-chave: Cálcio na dieta; Criança; Brasil; Laticínios.

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INTRODUCTION

Calcium is one of the minerals responsible for bone formation and mineralization when synthesizing hydroxyapatite crystals.¹ In childhood, adequate calcium intake is essential for bone accretion during skeletal growth and the range of bone mass peak suitable for prevention of osteoporosis and fractures in adulthood.² In addition, the intake of elemental calcium in the diet negatively correlates with cardiovascular disease by helping to reduce blood pressure through the renin-angiotensin-aldosterone system, decreasing fat absorption, and increasing lipolysis with lower lipid concentrations and body weight consequently.^{3,4}

Dietary calcium is mainly present in milk and dairy products, but foods, such as sardines, spinach, cabbage, and broccoli, are sources with a lower mineral concentration in daily diet. After ingestion, approximately 20–60% of dietary calcium is absorbed in the duodenum and jejunum, stimulated by calcitriol, the biologically active form of vitamin D. In addition, periods of physiological change, such as growth in childhood, puberty, pregnancy, and lactation, increase the percentage of calcium absorption to maintain adequate bone mineralization.¹

During childhood, the daily recommendation of dietary calcium increases gradually with age. According to the Sociedade Brasileira de Pediatria, infants in the first year of life should receive 200–260mg of dietary calcium. In contrast, preschoolers who aged between 2 and 6 years incomplete, and schoolchildren who aged between 7 and 12 years incomplete, as stated by the Estatuto da Criança e do Adolescente (ECA), should ingest approximately 700–1300mg of calcium. Despite this, in Brazil, according to the Pesquisa de Orçamentos Familiares 2017–2018, household consumption of dairy products decreased by 36% compared to 2002–2003, mainly fresh products.^{5,6}

In the first 2 years of life, milk intake predominates in the infants feeding, which guarantees the daily needs of calcium generally, but dairy consumption tends to decrease with the introduction of other types of food in the following years.⁷ Therefore, this study aimed to evaluate the adequacy of dietary calcium intake in Brazilian preschoolers and schoolchildren.

METHOD

A synthesis of evidence was performed through a narrative review, which either considered eligible experimental and observational comparative studies or not (i.e., cohort, case-control, and cross-sectional), which performed up to the time of the search, and which assessed the adequacy of the daily consumption of dietary calcium and milk and dairy products in healthy Brazilian children who aged between 2 and 12 years incomplete. Reports and case series, foreign studies, and articles including patients with preexisting comorbidities, such as lactose intolerance and cow's milk allergy (CMA), were excluded.

In September 2020, the search for evidence was conducted in MEDLINE database via PubMed – National Library of Medicine of the National Institutes of Health and Latin American and Caribbean Health Sciences Literature (LILACS) database via the Virtual Health Library (VHL). Chart 1 presents the search strategies elaborated for each database.

Two independent authors selected the studies obtained from the search using the Rayyan platform, a free web and mobile application, developed by the Qatar Computing Research Institute (QCRI) as an auxiliary tool for archiving, organizing, and selecting articles using a process of semi-automation.⁸ The first stage of the study selection was performed through the analysis of titles and abstracts. The studies considered potentially eligible were then evaluated in full text to verify the eligibility criteria by both independent authors. Finally, disagreements were resolved by a third reviewer, in consensus with the previous ones.

The data from the included studies were extracted and synthesized narratively, considering the following characteristics: the state where the study was performed, study design, sample size, age and gender of the participants, the instrument for evaluating outcomes (i.e., dietary recall, food frequency questionnaire, or direct weighing of food), values of calcium intake in milligrams (mg), and the percentage of the adequacy of daily intake of calcium or milk and dairy products intake in the diet.

Chart 1 Search strategies for each database.

MEDLINE (via PubMed)	#1 "Calcium, Dietary"[Mesh] OR (Dietary Calcium) OR (Calcium intake) #2 "Dairy Products"[Mesh] OR (Dairy Product) OR (Product, Dairy) OR (Products, Dairy) #3 #1 OR #2 #4 "Child"[Mesh] OR Children #5 "Brazil"[Mesh] #6 #3 AND #4 AND #5
LILACS (via VHL)	#1 MH:(Cálcio na Dieta) OR (Calcium, Dietary) OR (Calcio en la Dieta) OR D01.146.395 OR MH:Laticínios OR (Dairy Products) OR (Productos Lácteos) OR G07.203.300.350 OR J02.500.350 #2 MH:Criança OR Child OR Niño OR M01.060.406 #3 MH:Brasil OR Brazil OR Brasil OR Z01.107.757.176 #4 #1 AND #2 AND #3

RESULTS

The search in the databases resulted in 142 articles, of which 34 were selected for full reading after removal of duplicates and irrelevant articles. After selection, 18 manuscripts were considered eligible and selected to write this article (Figure 1).

The methodological characteristics of the selected studies, the types of intervention, and the results obtained are detailed in Tables 1–4. Nine studies evaluated dietary calcium intake,

seven estimated milk and dairy products consumption, and two performed both evaluations.

Among the 11 studies that evaluated dietary calcium intake by different methods, such as dietary recalls and weighted dietary records, 7 studies identified mean values below the recommended amount for age (Tables 1 and 2). Leroux et al.⁹ found a higher percentage of inadequate calcium consumption among 4-year-old preschoolers (93.3%) compared to children who aged 1–3 years (50%). Similarly, Martino et al.¹⁰ found

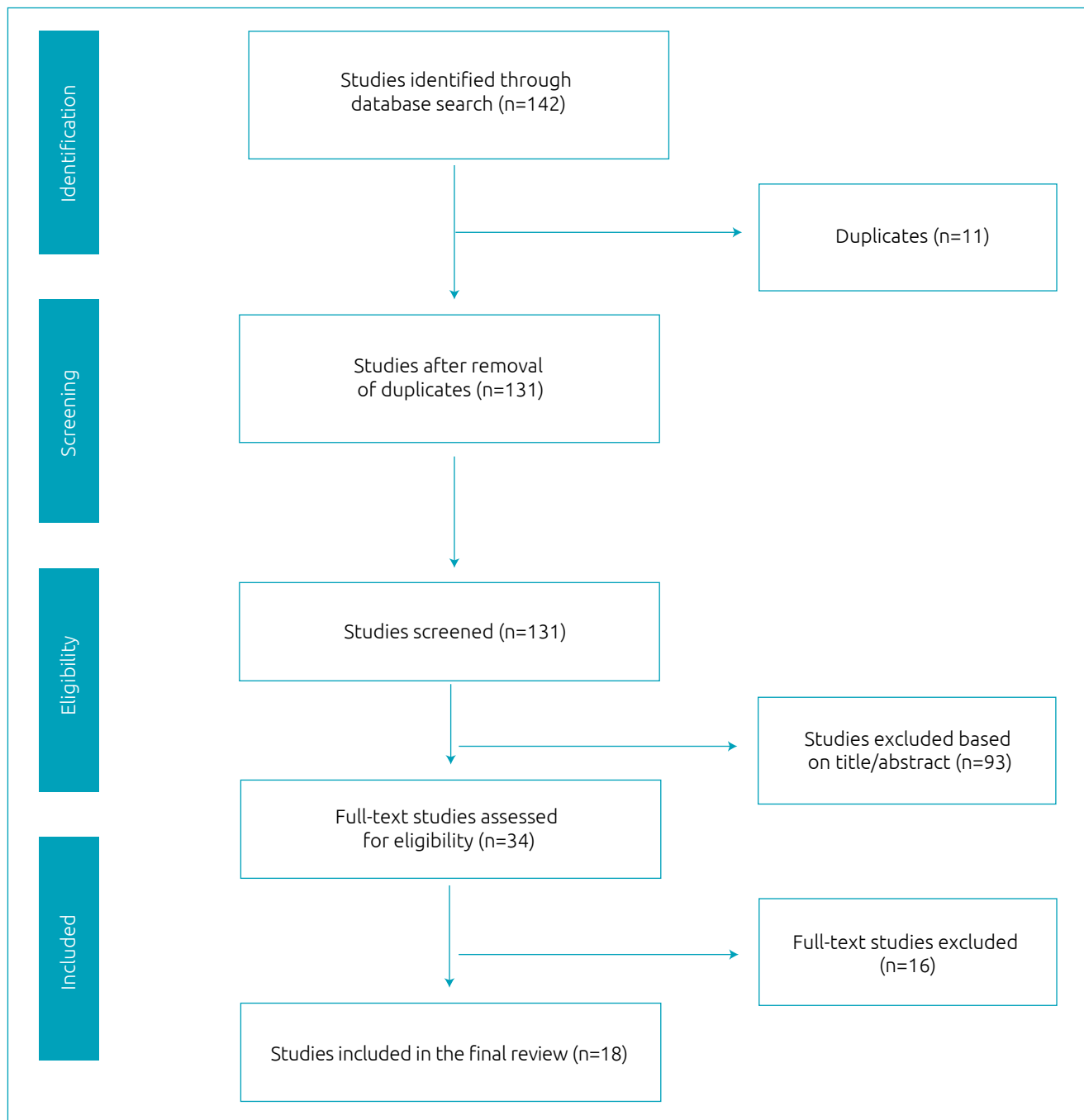


Figure 1 Flowchart of the study selection process.

lower dietary calcium intake values in all study children who aged 4–6 years.

By directly weighing the food offered in daycare centers and recalling the diet offered at home, Tavares et al.¹¹ and Bernardi et al.¹² found a lower prevalence of inadequate dietary calcium intake in preschoolers. In contrast, Bueno et al.¹³ identified lower dietary calcium consumption among preschoolers who aged 4–6 years than younger children.

When evaluating the daycare center and school schedule, Tavares et al.¹¹ concluded that children attending private daycare centers have a higher prevalence of calcium intake than public daycare students. Besides, Alencar et al.¹⁴ identified a more significant inadequacy of dietary calcium consumption among part-time preschoolers (61.1–78.2%) compared to full-time students (33.7%).

Among preschoolers, studies involving the direct weighing of foods showed a higher mean of dietary calcium values ingested than those performed with dietary recall.^{11–13}

In children who aged older than 6 years, dietary calcium intake progressively decreases with advancing age. All four studies with dietary recall identified low calcium consumption with values equivalent to half recommended for age.^{15–18}

Regarding the prevalence of adequate milk and dairy products intake, equivalent to three daily shares, Oliveira S. Filha et al.¹⁹ and Bortolini et al.²⁰ found percentages below 50% among preschoolers.⁵ In addition, Rauber et al.²¹ found higher

milk and dairy products consumption among preschoolers than schoolchildren in both control and intervention groups (Tables 3 and 4).

There is a reduction in the percentage of milk and dairy products intake with advancing age. Bielemann et al.²² noticed a higher consumption of dairy products in 4-year-old children than preschoolers who aged 6 years, with no significant difference between the sex. Bernardi et al.¹² found low values of inadequate dairy intake (13.4%) in preschoolers, and Martins et al.²³ identified inadequate milk intake (14.5%) in the same age group. In contrast, Pretto et al.²⁴ Levy-Costa et al.²⁵ identified 75% of 8-year-old children without the recommended consumption. corroborated this finding by identifying a progressive decrease in the percentage of milk and dairy products in the diet of preschoolers according to age.

DISCUSSION

Most of the studies evaluated in this review indicate a lower calcium intake in Brazilian preschoolers and schoolchildren because the identified values of dietary calcium and milk and dairy consumption were below the values recommended for each age group by the Sociedade Brasileira de Pediatria.⁵

Due to this fact, a diet rich in calcium should be stimulated in these age groups once this mineral is fundamental, during the child's longitudinal growth, for adequate bone formation

Table 1. Identification and methodological characteristics of the selected studies for dietary calcium intake evaluation.

Author	State	Study type	Sample n (M/F)	Age range (y)	Location	Instrument
Nascimento et al. ¹⁷	Ceará	Cohort	40 (17/23)	7–11.9	HH	Dietary recall
Martino et al. ¹⁰	Minas Gerais	CS	151 (82/69)	4–6	DCC	Weighted diet record
Scagliusi et al. ¹⁶	Acre	CS	61 (28/33)	6–9	HH	24-h dietary recall/food-frequency questionnaire
Tavares et al. ¹¹	Amazonas	CS	308 (161/147)	2–3	DCC/HH	DCC: weighted diet record HH: dietary recall
Bernardi et al. ¹²	Rio Grande do Sul	CS	362 (166/196)	2–6	DCC/HH	DCC: weighted diet record HH: dietary recall
Bueno et al. ¹³	Multicentre	CS	3,058 (1,571/1,487)	2–6	DCC/HH	DCC: weighted diet record HH: food diary
Castro et al. ²⁷	Multicentre	CS	2266 (1,158/1,108)	3–6	DCC/HH	DCC: weighted diet record HH: dietary recall
Magalhães et al. ¹⁸	Minas Gerais	CS	347 (142/205)	8–9	HH	Dietary recall
Alencar et al. ¹⁴	Piauí	CS	81 (42/39)	4–5	DCC	Food dietary record/ weighted diet record
Suhett et al. ¹⁵	Minas Gerais	CS	350 (166/184)	8–9	HH	24-h dietary recalls
Leroux et al. ⁹	São Paulo	CS	64 (34/30)	1–4	HH	24-h duplicate dietary recall

n: number, M: male, F: female, y: year, CS: cross-sectional, DCC: daycare center, HH: household.

and mineralization and consequent reduction of skeletal comorbidities, such as osteoporosis and fractures, in adulthood.²⁶⁻²⁸

The deficiency in calcium intake among children is associated with eating habits, ethnic and geographical differences, and cultural, socioeconomic, and lifestyle factors.²⁹ Given these factors, the performance of studies evaluated in different Brazilian states, whose population has peculiarities in culture, food, and socioeconomic status, may have contributed to the variations found in the evaluation of calcium consumption in preschoolers and schoolchildren.

Moreover, the research instrument may have contributed to the differences in dietary calcium intake results in preschoolers. The highest values were obtained in the studies with the

individual direct weighing of food, a more objective measure, than studies with a dietary recall. Dietary recalls and food diaries may not reflect the usual diet due to bias like the dependence on the memory of the interviewed person, alterations made by the patient to attend to the interviewer's expectations, and difficulties in food portion estimation.³⁰

Some studies of this review, such as the study by Tavares et al.,¹¹ Bernardi et al.,¹² and Rauber et al.,²¹ have shown a higher calcium intake in children who aged up to 4 years. During infancy, the encouragement of breastfeeding to reduce the chance of early weaning and the use of infant formulae may influence the consumption of milk and dairy products at the beginning of the preschool phase.³¹

Table 2 Results obtained from the selected studies regarding dietary calcium intake.

Author	Sample n (M/F)	Instrument	Dietary calcium reference range (mg)	Dietary calcium intake (mg)	Inadequate daily calcium intake % (n)
Nascimento et al. ¹⁷	40 (17/23)	Dietary recall	7–11.9 y: 1,100	466.8±293.6	97.5 (39)
Martino et al. ¹⁰	151 (82/69)	Weighted diet record	4–6 y: 1,000	182.4 [132.9; 229.0]	100
Scagliusi et al. ¹⁶	61 (28/33)	24-h dietary recall/food-frequency questionnaire	6–8 y: 1,000 9 y: 1,300	252.5	NA
Tavares et al. ¹¹	308 (161/147)	DCC: weighted diet record HH: dietary recall	2–3 y: 700	Public: 885.0±17.6 Private: 920.0±26.3	Public: 27.6 (60) Private: 7.9 (7) Total: 21.8 (67)
Bernardi et al. ¹²	362 (166/196)	DCC: weighted diet record HH: dietary recall	2–3 y: 700 4–6 y: 1,000	2–3y: 852.6±246.9 4–6y: 808.4±250.8	Public: 32.2 (83) Private: 33.7 (35) Total: 32.6 (118)
Bueno et al. ¹³	3,058 (1,571/1,487)	DCC: weighted diet record HH: food diary	2–3 y: 500 4–6 y: 800	2–3 y Public: 821.6 Private: 762.2 4–6 y Public: 804.1 Private: 792.3	2–3 y Public: 12.6 Private: 13.6 4–6 y Public: 48.9 Private: 40.3
Castro et al. ²⁷	2,266 (1,158/1,108)	DCC: weighted diet record HH: dietary recall	3 y: 700 4–6 y: 1,000	728.4±354.2	NA
Magalhães et al. ¹⁸	347 (142/205)	Dietary recall	8 y: 1,000 9 y: 1,300	458.4	NA
Alencar et al. ¹⁴	81 (42/39)	Food dietary record/ weighted diet record	4–5 y: 1,000	PT: 34.8±23.8 –62.3±49.1 FT: 371.1±142.1	PT: 61.1–78.2 FT: 33.7
Suhett et al. ¹⁵	350 (166/184)	24-h dietary recalls	NA	NA	97.4 (341)
Leroux et al. ⁹	64 (34/30)	24-h duplicate dietary recall	1–3 y: 700 4 y: 1,000	1–3 y: 500.8±207.3 4 y: 461.3±223.5	1–3 y: 50.0 (22) 4 y: 93.3 (18)

n: number, M: male, F: female, y: year, DCC: daycare center, HH: household; NA: not available, PT: part-time, FT: full-time, mean±standard deviation, median [minimum, maximum].

However, there is a progressive increase in the inadequacy of dairy and dietary calcium consumption with the advancement of chronological age, especially in those older than 6 years. In this age group,

socioeconomic conditions, the school food environment, parental food choices, dietary patterns, a greater consumption of soft drinks, industrialized juices, and other ultraprocessed foods are essential factors

Table 3 Identification and methodological characteristics of the selected studies for the intake of milk and dairy products evaluation.

Author	State	Study type	Sample n (M/F)	Age range (y)	Location	Instrument
Rauber et al. ²¹	Rio Grande do Sul	Cohort	276 (NA)	3–4; 7–8	HH	Dietary recall
Pretto et al. ²⁴	Rio Grande do Sul	Cohort	616 (316/300)	8	HH	Food Guide Based Questionnaire
Bielemann et al. ²²	Rio Grande do Sul	Cohort	3,316 (1,723/1,593)	4–6	HH	Dietary recall
Levy-Costa et al. ²⁵	São Paulo	CS	204 (NA)	2–5	HH	Dietary recall
Bernardi et al. ¹²	Rio Grande do Sul	CS	362 (166/196)	2–6	DCC/HH	DCC: weighted diet record HH: dietary recall
Oliveira S. Filha et al. ¹⁹	Sergipe	CS	65 (35/30)	2.0–2.9	HH	Dietary recall
Bortolini et al. ²⁰	Multicenter	CS	2,732 (NA)	2.0–4.9	HH	Dietary recall
Martins et al. ²³	Ceará	CS	200 (NA)	3–5	HH	Food Frequency Questionnaire
Suhett et al. ¹⁵	Minas Gerais	CS	350 (166/184)	8–9	HH	Dietary recall

n: number, M: male, F: female, y: year, CS: cross-sectional, NA: not available, DCC: daycare center, HH: household.

Table 4 Results obtained from the selected studies regarding the intake of milk and dairy products.

Author	Sample, n (M/F)	Instrument	Inadequate milk and dairy products intake, % (n)	Percentage of total daily calories derived from milk (%)
Rauber et al. ²¹	276 (NA)	Dietary recall	3–4 y Intervention: 23.4 (34) Control: 30.5 (61) 7–8 y Intervention: 57.3 (75) Control: 56.2 (99)	NA
Pretto et al. ²⁴	616 (316/300)	Food Guide-Based Questionnaire	75 (462)	NA
Bielemann et al. ²²	3,316 (1,723/1,593)	Dietary recall	4 y: M: 43.5 (749) F: 47.3 (753) 6 y: M: 51.5 (831) F: 59.3 (899)	NA
Levy-Costa et al. ²⁵	204 (NA)	Dietary recall	NA	24–35 mo: 21.8 36–47 mo: 20.6 48–60 mo: 13.1
Bernardi et al. ¹²	362 (166/196)	DCC: weighted diet record HH: dietary recall	13.2 (45)	NA
Oliveira S. Filha et al. ¹⁹	65 (35/30)	Dietary recall	55.4 (36)	NA
Bortolini et al. ²⁰	2,732 (NA)	Dietary recall	55.2 (1508)	NA
Martins et al. ²³	200 (NA)	Food Frequency Questionnaire	Milk: 14.5 (29) Dairy products: 60.5 (121)	NA
Suhett et al. ¹⁵	350 (166/184)	Dietary recall	34 (119)	NA

n: number, M: male, F: female, y: year, CS: cross-sectional, NA: not available, DCC: daycare center, HH: household, mo: months old.

influencing these outcomes.^{6,32} Moreover, more restrictive diets and food selectivity may have influenced this result. Vegetarian diets have become more common in various age groups due to health events and religious or philosophical principles. They can lead to calcium deficiency because they may contain large amounts of fibers, phytates, and oxalates, compounds capable of chelating calcium and reducing its passive absorption in the distal jejunum and ileum.³³⁻³⁶

Cow's milk is a potentially allergenic food, triggering atopic reactions in infants predisposed to lactose intolerance or CMA.³⁷ Nowadays, more than 60% of the world population has lactose intolerance, and its occurrence generally increases with age.³⁸ Therefore, lactose intolerance and CMA treatment involve restricting dairy products in the diet, which may compromise calcium intake in childhood without supplementation.^{37,39} Furthermore, misdiagnoses and the dissemination of lactose-free diets in healthy children can contribute to the low percentage of dairy products in their diets with a consequent reduction in calcium consumption.

The differences in calcium consumption between the private and public daycare centers demonstrate that the school team can dictate a greater or lesser inclusion of dairy products and calcium-rich foods in the child's diet. In addition, advertisements for foods low in calcium, such as soft drinks and ultraprocessed foods in school canteens, can induce an increasingly less nutritious and healthy diet.^{29,40} For example, soft drinks have a high concentration of caffeine and phosphate, increasing calciuria and decreasing bone mass gain.^{41,42}

For an adequate intestinal absorption of calcium, optimal levels of vitamin D are required. Despite its endogenous production by skin exposure to ultraviolet B sun rays, its dietary intake becomes essential to achieve daily needs in children with insufficient sun exposure. Bueno et al. identified higher inadequate vitamin D intake rates in preschoolers from private and public schools.^{13,26,43} Therefore, the fortification of foods with calcium and vitamin D is an alternative measure adopted to prevent or correct nutritional deficiencies. For example, the food industry of the United States and Canada already produces calcium and vitamin D-fortified foods with good bioavailability, such as apple and orange juices and breakfast cereals.^{44,45} However, these foods are still considered ultraprocessed and may increase the consumption of sugar and

food additives during childhood. Therefore, a policy to encourage the intake of fresh and nutrient-rich foods would be ideal for improving the nutritional health of preschool and school children.⁴⁶

Therefore, malnutrition, school nutrition policies, socioeconomic status of families, dissemination of restrictive diets without adequate nutritional support, increased diagnosis of lactose intolerance and CMA in childhood, and exceeding consumption of soft drinks and low calcium food may justify dietary calcium intake below the recommended values for age in preschoolers and schoolchildren.

One of the strengths of this study is the demonstration of the low consumption of dietary calcium in preschoolers and schoolchildren from different regions of Brazil through the compilation of cross-sectional and cohort studies that evaluated calcium, milk, and dairy products intake. Therefore, it is noteworthy that the narrative design of this review limited our ability to draw definite conclusions. Because of that, more investigations are needed to identify risk factors and adopt corrective measures, especially in schoolchildren, to reduce comorbidities during adulthood.

The inadequacy of dietary calcium intake seems to be prevalent in Brazil during childhood, mainly in schoolchildren. Therefore, the evaluation of milk and dairy products intake must be a point to be taken care of to carry out corrective measures in this age group.

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Conflict of interests

The authors declare there is no conflict of interests.

Authors' contribution

Study design: Galvão RA, Pavon B, Mórán MCB, Barbin MVC, Martimbianco ALC, Colares Neto GP. *Data collection:* Galvão RA, Pavon B, Mórán MCB, Barbin MVC. *Data analysis:* Galvão RA, Pavon B, Mórán MCB, Barbin MVC, Martimbianco ALC, Colares Neto GP. *Manuscript writing:* Galvão RA, Pavon B, Mórán MCB, Barbin MVC, Martimbianco ALC, Colares Neto GP. *Manuscript revision:* Martimbianco ALC, Colares Neto GP. *Study supervision:* Martimbianco ALC, Colares Neto GP.

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