



## Introduction to complementary feeding in the first year of life and risk of overweight at 24 months of age: changes from 2004 to 2015 Pelotas (Brazil) Birth Cohorts

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### Abstract

Complementary feeding (CF) and overweight relationships during early childhood are inconsistent in the literature. We described the association of CF during the first year of life with risk of overweight at 24 months of age in the population-based 2004 and 2015 Pelotas (Brazil) Birth Cohorts (2004c and 2015c). CF introduction was evaluated at the 3 and 12 months' follow-ups by asking mothers using a list of foods. Risk of overweight at 24 months of age was BMI-for-age z-score above +1SD from the median of the WHO 2006 growth standards. Our analyses included 3823 (2004c) and 3689 (2015c) children. Early introduction CF (before 6 months of age) prevalence in 2004c was 93.3 (95% CI 92.5, 94.1)% and in 2015c was 87.2 (95% CI 86.1, 88.2)%. Tea was the item introduced earlier in both 2004c (68.8%) and 2015c (55.7%). At 6 months of age, vegetable mash was the most introduced food in 2004c (33.5%) and 2015c (47.9%). Between 2004c and 2015c, the introduction of fresh milk decreased 82.1 to 60.5% and yogurt from 94.4 to 78.1% during the first year. Risk of overweight prevalence at 24 months was 33.0 (95% CI 31.6, 34.5)% in 2004c and 32.0 (95% CI 30.5, 33.5)% in 2015c. In 2015c, the adjusted odds of risk of overweight at 24 months were increased 1.66 and 1.50 times with the early introduction of fresh/powdered milk: plus water, tea or juice, and plus semi-solid/solid food groups, respectively. It is essential to reinforce the adherence to global recommendations on timely feeding introduction and encourage exclusive breast-feeding until 6 months of age to prevent child overweight.

**Key words:** Overweight; BMI z-score; Complementary feeding; Longitudinal studies; Brazil

Childhood overweight and obesity are global problems that affect about 40 million of children under 5 years of age from low-, middle- and high-income countries. Overweight and obese children have higher odds to remain obese in adulthood and more likely to develop non-communicable diseases, such as early onset of diabetes type 2 and CVD<sup>(1)</sup>.

Recent evidence has shown that complementary feeding practices are important predictors of rapid weight gain during infancy<sup>(2,3)</sup>. Adequate nutrition during the first 2 years of life is essential to ensure children reach their potential for growth and development<sup>(4,5)</sup>. The WHO recommends exclusive breast-feeding (EBF) up to 6 months of age<sup>(4)</sup>, because at this age the demand for energy and nutrients increases and complementary

foods are needed. These complementary foods should be introduced gradually in diversity and quantity until the total incorporation to the family diet is reached, and always together with breast milk<sup>(4,6)</sup>. The introduction of complementary feeding requires the presence of different food groups (vegetables/legumes, grain/tubers, beans and meat/egg/offal) without the inclusion of sugar or items such as salty snacks, sweets and processed foods<sup>(4)</sup>.

An inadequate quantity and quality, or an early introduction of complementary feeding, have been associated with nutritional problems in children<sup>(3)</sup>. In a birth cohort study from Italy, it was observed that 86% of infants were already receiving complementary foods at 6 months of age<sup>(7)</sup>. Another longitudinal

**Abbreviations:** 2004c, 2004 Birth Cohort; 2015c, 2015 Birth Cohort; BF, breast-feeding; EBF, exclusive breast-feeding.

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study showed that four out of five Canadian mothers introduced complementary foods to their children before 6 months of age<sup>(8)</sup>. In a Brazilian cross-sectional study, more than half of infants were being fed with fruits (62.7%), juices (57.2%) and savoury foods (55.1%) before 6 months of age<sup>(9)</sup>.

Recent original studies in high-income countries suggest that an early food introduction (i.e. before 6 months of age) may increase the risk of childhood overweight/obesity<sup>(6,10-12)</sup>. Additionally, in a meta-analysis was observed that an increased risk of being overweight or obese during childhood was associated with an introduction of complementary foods before 4 months of age<sup>(13)</sup>. Conversely, in the Nurses' Health Study II in the USA was found that the late introduction of solid foods was marginally associated with obesity at 5 years of age, although this association did not persist over time<sup>(14)</sup>. Hence, the evidence is still controversial in this regard.

It is known that early-life exposures can determine health and disease in adulthood. Although there is evidence that the timing of solid-food introduction may be a modifiable obesity risk factor at an early age<sup>(14)</sup>, few studies have measured or described the age and type of foods introduced for the first time to infants in low- and middle-income countries. Therefore, we aimed to describe the introduction of complementary foods during the first 12 months of age, and the association of an early food introduction with the risk of overweight at 24 months in the 2004 and 2015 Pelotas Birth Cohorts.

## Material and methods

The 2004 and 2015 Pelotas Birth Cohorts are two ongoing population-based longitudinal studies conducted in the city of Pelotas. Pelotas is a medium-size municipality situated in Southern Brazil with approximately 340 000 inhabitants (2018 Brazilian population census). In the city, there are four birth cohort studies: 1982<sup>(15)</sup>, 1993<sup>(16)</sup>, 2004<sup>(17)</sup> and 2015<sup>(18)</sup>. For the purpose of the present study, data were analysed from the 2004 and 2015 Pelotas Birth Cohorts, since these studies have comparable information on food introduction.

### 2004 Birth Cohort (2004c)

All babies born between 1 January and 31 December 2004 from mothers who lived in the urban area of Pelotas or in the near neighbourhood of Jardim América (part of the municipality of Capão do Leão) were enrolled in 2004c. In the first 24 h after childbirth, 99.2% ( $n$  4231) of all mothers were interviewed, and the newborns were evaluated at the maternity hospitals. Questionnaires were used to collect maternal, parental, child and household information. The follow-up rates when children were 3, 12 and 24 months old were 95.7, 94.2 and 93.4%, respectively. More details about the 2004c follow-up visits have been reported previously<sup>(17,19)</sup>.

### 2015 Birth Cohort (2015c)

Different from previous cohort studies, 2015c attempted to recruit pregnant women during antenatal care, rather than women shortly after delivery. Recruitment strategies adopted were the same as those used in the three previous cohorts. Of

all deliveries, 99.9% ( $n$  4387) were recruited. Most mothers of eligible newborns were interviewed on the first day after delivery (96.7%), whereas 2.5% of the mothers were interviewed on the second day after delivery (completing a 99.2% rate of assessment at birth). The follow-up rates when children were 3, 12 and 24 months old were 97.2, 95.4 and 93.9%, respectively. Further details of 2015c follow-ups can be found in another publication<sup>(18)</sup>.

### Risk of overweight at 24 months of age

At 24 months of age, the length and weight of 2004c and 2015c children were measured at home. Children's weight was assessed using a digital scale with a precision of 100 g and a maximum capacity of 150 Kg: Tanita® BC-558 Ironman Segmental Body Composition Monitor in 2004c and Tanita® UM80 scales in 2015c (TANITA). The scale was placed on a firm and a level surface. Mothers were weighed while holding the child, wearing minimal clothing and no shoes, and with the weight distributed equally on the two feet placed centrally on the scale. Then, the mother was weighed without the baby. The baby's weight was obtained by subtracting the mother's weight from the weight of the mother plus the baby. It was requested that the child remained undressed during the weighing process, but in the cases that this was not allowed by the mother, the baby's clothes were noted and later the weight of those clothes was subtracted from the baby's weight. Length was measured in centimetres with the baby lying in supine position, using portable infantometers with 1 mm of precision: Altorexata® maximum 2.13 m in 2004c and Harpenden (Chasmors), 30 to 110 cm amplitude in 2015c.

Children were classified with risk of overweight if they presented a BMI-for-age  $z$ -score above one standard deviation from the median of the WHO 2006 child growth standard<sup>(20-22)</sup>.  $Z$ -score values above +5 or below -5 were considered implausible and were excluded from the analysis (nine children in 2004c and ten in 2015c).

### Complementary feeding during the first 12 months

Information on complementary feeding was obtained at 3 and 12 months of age in both 2004c and 2015c. Using a food list at the 3 months' follow-up, mothers of the two cohorts were asked about the timing of complementary feeding. The following question was applied: 'When has <INFANT'S NAME> begun to eat regularly (being presented one by one the foods of the following list): fresh milk, powdered milk, tea, water, juice, fruit mash, soup, vegetable mash, porridge, egg or other food?'

At 12 months of age, mothers were asked the following in both cohorts studies: 'Now, I am going to tell you a list of liquids and foods and let me know if you have started giving to <INFANT'S NAME>. When I say 'started', I want to know if <INFANT'S NAME> receives or received that liquid or food every day, or almost every day of the week. If you have already started giving, I want to know when you have started: fresh milk, powdered milk, tea, juice, fruit mash, soup, vegetable mash, porridge, egg (yolk), egg (white), yogurt, bread or cracker, meat, bean broth, bean grain, rice, pasta and legumes/vegetables (in pieces) or other food?'. In 2015c, at 12 months' follow-up, the

mother was asked about the age of soft drink introduction. The questionnaires are available in an electronic format (<http://www.epidemiio-ufpel.org.br>).

When there was a disagreement about the age of introduction of a specific food reported at the 3 and 12 month, the earlier recorded age was maintained. 'Egg yolk' or 'egg white' were considered as 'egg'. Water introduction was assessed only at 3 months of age in both cohorts. Fresh milk refers to cows' milk or other type of non-human milk in sachet, bottle or box. Powdered milk included infant formula, cows' milk or another type of non-human milk in powder. No information was collected on the frequency or portion sizes consumed for any food items.

We evaluated the timing of introduction in months in infants (<12 months of age) and the early introduction of complementary feeding (<6 months of age). An early complementary feeding introduction was defined when the mother had introduced to his/her child before 6 months of age any food from the food list or another different food from the food list. The latter was obtained in an open question available at the end of the food list.

### Complementary feeding pattern before 6 months of age

To verify the association between complementary feeding introduction before 6 months of age and the risk of overweight at 24 months, we considered the type of milk consumed by the infant and the food introduced using three broad food groups: liquids (water, tea or juice), semi-solids (fruit mash, vegetable mash, yogurt, soup, porridge, bean broth and bean grain) and solids (meat, egg, pasta, rice, bread or cracker and vegetable in pieces). Other foods informed by the mother were also grouped into liquids, semi-solid and solid foods.

The feeding pattern variable was classified into seven categories: (1) EBF; (2) breast-feeding (BF) plus water, teas or juices; (3) BF plus fresh or powdered milk (may receive liquids or not); (4) BF plus semi-solids or solid foods (may receive liquids or not); (5) exclusive fresh milk or powdered milk; (6) fresh or powdered milk plus water, teas or juices; and (7) fresh or powdered milk plus semi-solids or solid foods (may receive liquids or not).

### Other independent variables

Perinatal information on socio-demographic and behavioural characteristics from both 2004c and 2015c was collected: sex (male/female), birth weight (g), gestational age (weeks), type of delivery, non-EBF until 6 months of age (yes/no), maternal age (years), marital status (with/without partner), parity (number), antenatal care visits (number), national wealth index in quintiles (Brazilian National Economic Indicator quintiles, the 1° quintile being the poorest and the 5° quintile the wealthiest)<sup>(23)</sup>, maternal schooling (years) and pre-gestational BMI (kg/m<sup>2</sup>).

### Statistical analysis

Proportions and 95% CI for categorical variables were calculated. We used Pearson  $\chi^2$  test to assess association between early introduction of complementary feeding and covariates. Bivariate and multivariate logistic regression models assessed the association between complementary feeding practices and

the risk of overweight when children were 24 months old. The OR of early introduction of food before 6 months of age and the risk of overweight at 24 months of age were obtained. Additionally, we tested the hypothesis that child sex modifies the association of early introduction of complementary feeding with the risk of overweight at 24 months of age with an interaction term between child sex and early introduction of complementary feeding. In our sample, the interaction test was not statistically significant ( $P > 0.1$ ). The association between early introduction of complementary feeding and excessive weight at 24 months was adjusted for infant (birth weight, gestational age and type of delivery) and maternal characteristics (age, marital status, parity, antenatal care visits, national wealth, schooling and pre-gestational BMI).  $P$  values <0.05 were considered statistically significant. All analyses were conducted using Stata version 16.0 (StataCorp).

### Ethical considerations

The parents or caregivers from 2004c and 2015c received detailed information about the studies' objectives and procedures. Interviews and examinations were conducted only after obtaining written consent. Confidentiality of information was warranted. Subjects were aware that their participation in the studies was voluntary and were assured that they could withdraw from participation at any time without giving reasons. The Research Ethics Committee from the Faculty of Medicine of the Federal University of Pelotas approved 2004c, and the registration process numbers are 4-06-00-006 and 4-06-01-113 for 2015c. The 2015c study protocol was reviewed and approved by the School of Physical Education Ethics Committee at the Federal University of Pelotas (CAAE registration number: 26746414.5.0000.5313).

### Results

Table 1 shows infant and maternal characteristics obtained during the perinatal visits of the 2004 and 2015 Birth Cohorts. A total of 4231 and 4275 live births were identified in 2004c and 2015c, respectively. Children with valid and complete information of feeding introduction in the first year of life and anthropometric measures at 24 months of age were 3823 in 2004c and 3689 in 2015c. In 11 years, there was an increase in the number of Caesarean section deliveries (45.3 *v.* 64.6%) and in prevalence of maternal pre-gestational obesity (11.1 *v.* 19.2%). Prevalence of any BF for 6 months or longer, mothers who were 30 years old or more at child's birth, who attended six or more antenatal care visits, and had twelve or more completed years of education had also increased in the period.

The cumulative proportions of complementary feeding practices over the first year of life in 2004c and 2015c are shown in Fig. 1. Before 1 month of life, in 2004c, 30.6% of children had already received tea and 10.7% was receiving powdered milk (Fig. 1(a)). Eleven years later, the proportion of newborns receiving tea was reduced from 30.6 to 21.7%, while powdered milk introduction rate duplicated (22.0%) (Fig. 1(b)). Although the proportion of tea introduction decreased from 2004c to 2015c, at 3 months old over 50% of the children in both cohorts were receiving this beverage. At 3 months, in 2004c, 42.5% of children



**Table 1.** Infant and maternal characteristics from the perinatal visits of the 2004 and 2015 Birth Cohorts, Pelotas, Brazil, 2019 (Numbers and percentages)

Characteristics	2004 Birth Cohort					2015 Birth Cohort					P*		
	Perinatal (n 4231)		Diet information and anthropometric measures (n 3823)			Perinatal (n 4275)		Diet information and anthropometric measures (n 3689)					
	n	%	n	P†	%	n	%	n	P†	%			
<b>Infant</b>													
Sex											0.5	0.7	0.2
Male	2195	51.9	1990		52.1	2164	50.6	1871		50.7			
Female	2036	48.1	1833		47.9	2111	49.4	1818		49.3			
Birth weight (g)											<0.001	0.001	0.5
<2500	423	10.0	342		8.9	182	9.2	347		9.4			
2500 or more	3803	90.0	3480		91.1	1787	90.8	3340		90.6			
Gestational age											<0.001	<0.001	0.4
<37 weeks	612	14.5	526		13.8	663	15.5	534		14.5			
37 weeks or more	3603	85.5	3293		86.2	3612	84.5	3155		85.5			
Type of delivery											0.6	0.06	<0.001
Normal	2308	54.6	2092		54.7	1489	34.8	1305		35.4			
Caesarean section	1921	45.4	1731		45.3	2785	65.2	2383		64.6			
Breast-feeding duration											<0.001	<0.001	<0.01
<6 months	2068	50.5	1925		50.4	1961(83.2)	47.3	1704		46.2			
6 months or more	2014	49.5	1898		49.6	2186(16.8)	52.7	1985		53.8			
<b>Maternal</b>											0.5	0.7	<0.001
Age (years)													
<20	799	18.9	715		18.7	622	14.6	540		14.6			
20–29	2107	49.8	1903		49.8	2017	47.2	1732		47.0			
30 or more	1321	31.3	1203		31.5	1635	38.3	1416		38.4			
Marital status											0.02	0.04	<0.01
With partner	3536	83.6	3212		84.0	3667	85.8	3180		86.2			
Without partner	693	16.4	611		16.0	607	14.2	508		13.8			
Parity											0.8	0.9	<0.001
1	1665	39.4	1506		39.4	2174	50.9	1839		49.9			
2	1110	26.3	1008		26.4	1341	31.4	1140		30.9			
3 or more	1453	34.4	1308		34.2	759	17.8	708		19.2			
Antenatal care visits											<0.001	<0.001	<0.001
<6	769	19.0	653		17.8	586	14.1	467		12.9			
6 or more	3281	81.0	3012		82.2	3583	85.9	3146		87.1			
Wealth index (quintiles)											0.5	0.004	0.3
1° (poorest)	707	21.7	663		21.5	824	20.0	716		20.1			
2°	620	18.9	587		19.1	829	20.1	740		20.8			
3°	635	19.5	607		19.7	820	19.9	720		20.2			
4°	650	19.9	615		20.0	823	19.9	692		19.4			
5° (wealthiest)	653	20.0	610		19.8	831	20.1	698		19.5			
Education (years)											0.2	0.001	<0.001
0–4	654	15.6	584		15.4	391	9.2	332		9.0			
5–8	1731	41.4	1563		41.3	1095	25.6	963		26.1			
9–11	1381	32.9	1265		33.4	1458	34.1	1280		34.7			
12 or more	420	10.0	372		9.8	1330	31.1	1113		30.2			
Nutritional status (pre-gestational)											0.3	0.07	<0.001
Underweight	182	4.8	169		4.8	154	3.7	137		3.8			
Adequate	2271	60.8	2134		60.7	2039	49.2	1766		49.3			
Overweight	873	23.4	825		23.5	1169	28.2	989		27.6			
Obesity	409	11.0	389		11.1	779	18.8	689		19.2			

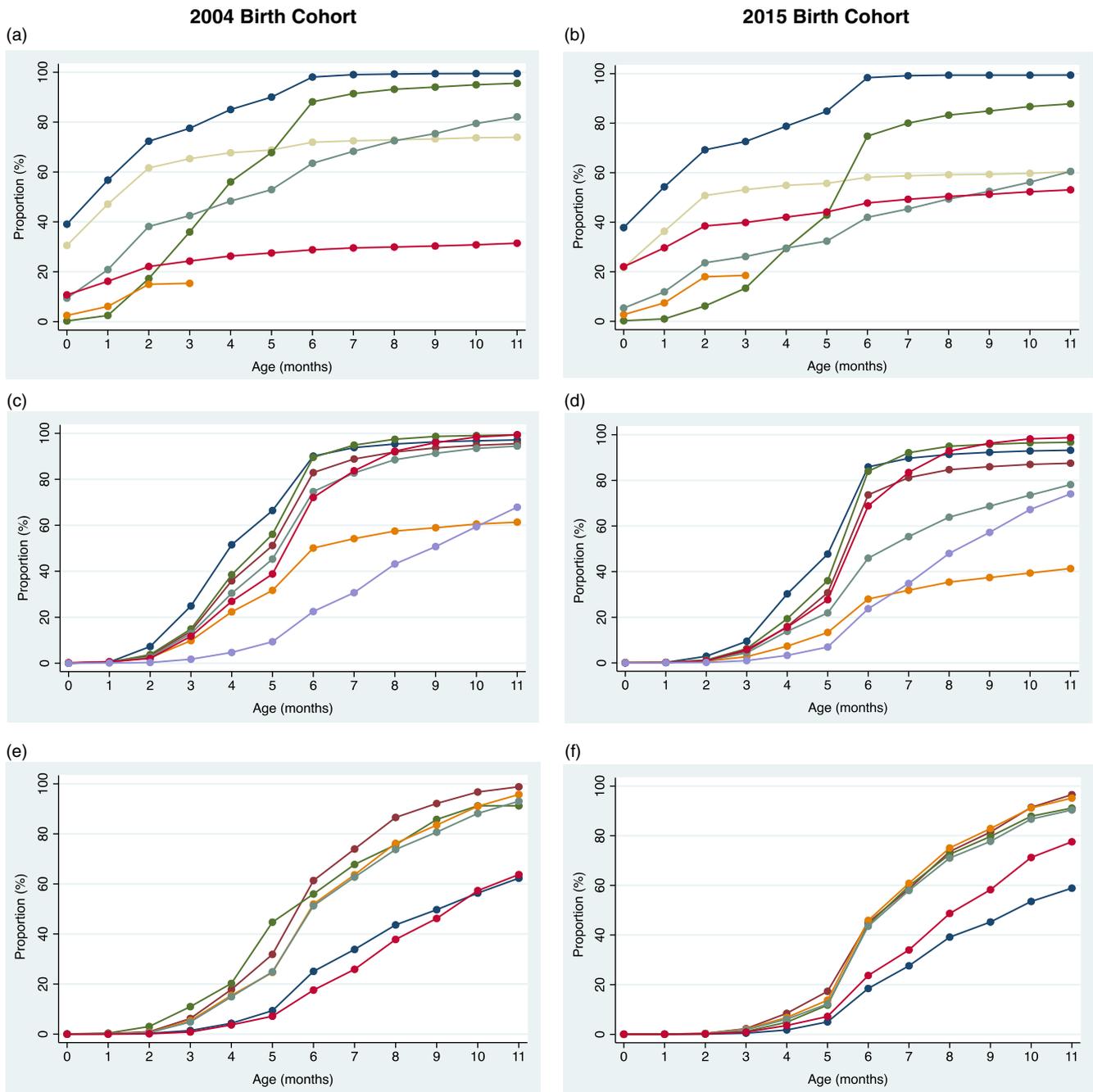
\* Study sample data 2004 and 2015 Birth Cohorts.

† Study sample data and perinatal participants.

had been introduced fresh milk and 25 % introduced powdered milk. In 2015c, the proportion of children receiving fresh milk decreased to 26.2 % and the proportion receiving powdered milk increased to approximately 40.0 %.

Water introduction was assessed only up to 3 months of age, and the prevalence was similar in 2004c and 2015c (15.4 and 18.5 %, respectively). At this age, there was a reduction in prevalence of introduction of fruit mash between the two cohorts (24.9 % in 2004c *v.* 9.5 % in 2015c). At 6 months,

vegetable mash was the most introduced food in both 2004c (33.5 %) and 2015c (47.9 %), followed by soup and bean broth. Before 12 months of age, the main reductions in proportion of complementary foods introduced to children from 2004c to 2015c were in fresh milk (82.1 to 60.5 %), tea (73.9 to 60.4 %) (Fig. 1(a) and (b), porridge (61.4 to 41.4 %) and yogurt (94.4 to 78.1 %) (Fig. 1(c) and (d)). Regarding vegetables (in pieces), introduction under 12 months increased from 63.7 to 77.6 % in 11 years.



**Fig. 1.** Cumulative proportion of infant-feeding introduction during the first year of life by groups: (a) and (b) liquids, (c) and (d) semi-solids and (e) and (f) solids. 2004 and 2015 Birth Cohort studies of Pelotas, Brazil, 2019. (a and b) (—●—), any food; (—●—), tea; (—●—), juice; (—●—), water; (—●—), fresh milk; (—●—), powdered milk. (c and d) (—●—), fruit mash; (—●—), soup; (—●—), vegetable mash; (—●—), porridge; (—●—), yogurt; (—●—), bean broth; (—●—), bean grain. (e and f) (—●—), egg; (—●—), bread; (—●—), meat; (—●—), rice; (—●—), pasta; (—●—), vegetable (piece).

The early introduction of liquids, semi-solids or solids in the two cohorts is presented in Table 2. In 2004c, 93.3 (95% CI 92.5, 94.1) % of children were introduced foods earlier than 6 months old, and 11 years later this prevalence decreased to 87.2 (95% CI 86.1, 88.2) %.

From the eighteen food/beverage items, tea was the item with the highest proportion of children receiving it before 6 months of age (68.8%), followed by juice (67.8%) and fruit mash (67.0%). In 2015c, tea continued to be the item with the highest proportion of early introduction (55.7%). The proportion of children with early introduction of powdered milk increased from 27.5% in 2004c to 44.1% in 2015c. Conversely, there was a reduction in the prevalence of

**Table 2.** Liquid, semi-solid or solid food introduction before 6 months of age in the 2004 and 2015 Birth Cohorts, Pelotas, Rio Grande do Sul, Brazil, 2019\* (Numbers and percentages)

Food/beverage	2004 Birth Cohort				2015 Birth Cohort			
	Total <i>n</i>	<i>n</i>	%	95% CI	Total <i>n</i>	<i>n</i>	%	95% CI
Any food + other foods*	3782	3404	93.3	92.5, 94.1	3659	3190	87.2	86.1, 88.2
Liquids								
Fresh milk	3785	2003	52.9	51.3, 54.5	3645	1180	32.4	30.9, 33.9
Powdered milk	3765	1037	27.5	26.1, 29.0	3643	1608	44.1	42.5, 45.8
Tea	3794	2611	68.8	67.3, 70.3	3656	2036	55.7	54.1, 57.3
Juice	3772	2557	67.8	66.3, 69.3	3623	1553	42.9	41.3, 44.5
Water†	3751	576	15.4	14.2, 16.5	3664	678	18.5	17.3, 19.8
Semi-solids								
Fruit mash	3763	2499	66.4	64.9, 67.9	3623	1728	47.7	46.1, 49.3
Soup	3762	1926	51.2	45.6, 52.8	3621	1114	30.8	29.3, 32.3
Vegetable mash	3764	2111	56.1	54.5, 57.7	3621	1305	36.0	34.5, 37.6
Porridge	3762	1192	31.7	30.2, 33.2	3618	483	13.4	12.3, 14.5
Bean broth	3762	1460	38.8	37.3, 40.4	3622	1003	27.7	26.3, 29.2
Bean grain	3758	351	9.3	8.4, 10.3	3620	252	7.0	6.2, 7.8
Yogurt	3761	1703	45.3	43.7, 46.9	3621	793	21.9	20.6, 23.3
Solids								
Egg	3762	352	9.4	8.5, 10.3	3619	181	5.0	4.3, 5.8
Bread/cracker	3759	1197	31.8	30.4, 33.4	3621	627	17.3	16.1, 18.6
Meat	3760	761	20.2	19.0, 21.6	3620	425	11.7	10.7, 12.8
Rice	3762	927	24.6	23.3, 26.0	3619	497	13.7	12.6, 14.9
Pasta	3760	935	24.9	23.5, 26.3	3620	443	12.2	11.2, 13.3
Vegetables (piece)	3572	255	7.1	6.3, 8.0	3618	260	7.2	6.4, 8.1

\* All diet items, including other foods maternal report.

† Evaluated up to 3 months age.

early introduction of yogurt (45.3% in 2004c *v.* 21.9% in 2015c), porridge (31.7% in 2004c *v.* 13.4% in 2015c) and pasta (24.9% in 2004c *v.* 12.2% in 2015c).

Infant and maternal characteristics associated with liquids, semi-solids or solids food introduction before 6 months of age are shown in Table 3. In both cohorts, an earlier feeding introduction was more prevalent in children with BF duration less than 6 months (99.7 and 98.1%), and whose mothers were younger than 20 years old (95.3 and 93.7%), belonged to the poorest wealth quintile (95.3 and 91.7%), and has less than 4 years of schooling education (95.8 and 94.2%). Additionally, in the 2015c earlier introduction of complementary feeding was more prevalent among children with birth weight < 2500 g, who were born < 37 weeks, and whose mothers lived without a partner, had three or more children, attended fewer than six antenatal care visits, and were obese before getting pregnant.

At 24 months of age, the risk of overweight prevalence was 33.0 (95% CI 31.6, 34.5)% and 32.0 (95% CI 30.5, 33.5)% in 2004c and 2015c, respectively. In 2004c, there was no sex difference. Although we found that in 2015c the prevalence of risk of overweight children was higher in boys than in girls (34.2 *v.* 29.8%, respectively;  $P < 0.01$ ), the prevalence of risk of overweight was higher in girls who introduced liquids, semi-solids or solids before 6 months of age compared with boys (30.9 *v.* 22.6%;  $P < 0.01$ ) – data not shown in the table.

The crude and adjusted associations between early introduction of complementary feeding and risk of overweight at 24 months are shown in Table 4. In 2004c, no statistically significant association was observed between early introduction of complementary feeding and risk of overweight at 24 months. However,

11 years later, 2015c infants who received fresh or powdered milk plus water, teas or juices and infants who were introduced fresh or powdered milk plus semi-solids or solids foods (liquids or not) had 1.66 and 1.50 higher odds to be risk of overweight at 24 months, respectively, compared with infants who received EBF.

## Discussion

The present study shows that complementary feeding practices changed over a period of 11 years. The overall food introduction prevalence was lower in children from 2015c when compared with children from 2004c, especially fresh milk and dairy products (yogurt and porridge). Conversely, powdered milk introduction prevalence increased considerably over time. Additionally, in both cohorts, tea was the food that was mostly introduced before the first month of life. One positive aspect to highlight is the increase in the vegetable (in pieces) introduction prevalence before 12 months of age between the two cohorts. Although the prevalence of early food introduction of complementary food was reduced about six percentage points, 11 years later it remained high (87.2%). Furthermore, early introduction of complementary food in 2015c increased the odds of risk of overweight at 24 months of age.

Infant-feeding practices during the first year of life are determinants of eating habits and nutritional status of children. Long-term benefits of breast milk on growth and child development during the first year of life are well documented (protection against infections and dental malocclusion, increase in intelligence and

**Table 3.** Liquid, semi-solid or solid food introduction\* before 6 months of age according to infant and maternal characteristics in the 2004 and 2015 Birth Cohorts, Pelotas, Brazil, 2019 (Numbers and percentages)

Characteristics	2004 Birth Cohort (n 3823)			2015 Birth Cohort (n 3659)		
	n	%	P	n	%	P
<b>Infant</b>						
Sex			0.2			0.2
Male	1850	93.9		1634	87.9	
Female	1621	92.7		1556	86.5	
Birth weight (g)			0.09			<0.01
<2500	322	95.5		319	92.2	
2500 or more	3206	93.1		2869	86.7	
Gestational age (weeks)			0.06			0.02
<37	495	93.0		482	90.4	
37 or more	3030	95.2		2708	86.6	
Type of delivery			0.5			0.1
Normal	1938	93.5		1144	88.3	
Caesarean section	1591	93.0		2045	86.5	
Breast-feeding duration			<0.001			<0.001
<6 months	1891	99.7		1652	98.1	
6 months or more	1638	86.9		1538	77.9	
<b>Maternal</b>						
Age (years)			0.01			<0.001
<20	674	95.3		505	93.7	
20–29	1759	93.5		1523	88.6	
30 or more	1094	91.8		1161	83.0	
Marital status			0.06			<0.001
Without partner	580	92.9		475	94.3	
With partner	2949	90.2		2714	83.9	
Parity			0.1			0.001
1	1394	93.6		1617	88.4	
2	917	92.0		944	83.5	
3 or more	1217	94.0		627	89.8	
Antenatal care visits			0.3			<0.001
<6	608	94.1		1133	90.7	
6 or more	2769	89.5		1985	85.1	
Wealth index (quintiles)			<0.03			<0.001
1° (poorest)	625	95.3		673	91.7	
2°	548	94.0		666	88.5	
3°	553	92.0		616	84.9	
4°	555	91.3		593	84.1	
5° (wealthiest)	552	91.7		527	74.1	
Education (years)			<0.001			<0.001
0 to 4	552	95.8		310	94.2	
5 to 8	1460	94.6		889	93.1	
9 to 11	1156	92.1		1132	88.8	
12 or more	327	88.9		858	78.1	
Nutritional status (pre-gestational)			0.1			<0.001
Underweight	158	95.8		119	85.2	
Adequate	1953	92.3		1455	83.3	
Overweight	775	94.4		890	90.4	
Obesity	355	92.9		628	91.7	

\* Includes 'Other foods'.

probable reductions in overweight and diabetes)<sup>(24,25)</sup>. However, age of introduction of complementary feeding has received less attention<sup>(2)</sup>. Complementary feeding defined as the transition from breast milk to the family diet should occur when breast milk is no longer enough to fulfil child nutritional requirements<sup>(4)</sup>. The WHO recommends EBF up to 6 months of age, followed by continuous BF along with the introduction of appropriate complementary foods.

Inadequate complementary feeding practices have been associated with increased morbidity, especially infectious diseases, micronutrient deficiencies and overweight/obesity that directly impact child health<sup>(26)</sup>. In our study, it was found that

93.3 and 87.2% of children from 2004c and 2015c, respectively, were introduced any food before 6 months of age. These findings are comparable with previous studies. In Northeast Brazil, a birth cohort study showed that 96.7% of the children receive any liquid, semi-solid or solid before 6 months of age<sup>(3)</sup>. Likewise, in the Southampton Women's Survey from UK, 95% of the mothers introduced solid foods to their infants before 6 months of age<sup>(27)</sup>.

It is possible that the reduction in early complementary food introduction observed in the present study occurred due to many actions carried out in Brazil to incentive BF and healthy complementary feeding, such as implementation of the Baby Friendly

**Table 4.** Feeding pattern before 6 months of age and association with overweight at 24 months in the 2004 and 2015 Birth Cohorts, Pelotas, Brazil, 2019\* (Numbers and percentages)

Feeding pattern 6 months	2004 Birth Cohort						2015 Birth Cohort					
	n (n 3758)	%	OR		Adjusted† (n 2711)	OR	n (n 3538)	%	OR		Adjusted† (n 3282)	OR
			Crude†	95% CI					Crude†	95% CI		
Exclusive BF	231	6.2	Ref.	–	Ref.	443	12.5	Ref.	–	Ref.	–	Ref.
BF + liquids	260	6.9	0.86	0.59, 1.25	0.81	243	6.9	1.11	0.79, 1.57	1.06	0.73, 1.53	1.06
BF + fresh/powdered milk (liquids or not)	159	4.2	1.17	0.77, 1.78	1.19	295	8.3	1.29	0.94, 1.79	1.22	0.87, 1.71	1.22
BF + semi-solids or solids (liquids or not)	1407	37.4	0.84	0.62, 1.12	0.89	999	28.2	1.15	0.90, 1.48	1.15	0.89, 1.50	1.15
Exclusive fresh/powdered milk	7	0.2	2.57	0.56, 11.7	2.31	64	1.8	1.22	0.69, 2.16	1.35	0.74, 2.46	1.35
Fresh/powdered milk + liquids	159	4.2	0.86	0.56, 1.32	0.89	378	10.7	1.60	1.19, 2.15	1.66	1.21, 2.29	1.66
Fresh/powdered milk + semi-solids or solids (liquids or not)	1535	40.9	1.07	0.80, 1.43	1.17	1116	31.5	1.46	1.15, 1.87	1.50	1.15, 1.95	1.50

BF, breast-feeding.

\* P < 0.05. Model adjusted: birth weight, gestational age, type of delivery, maternal age, marital status, parity, antenatal care visits, wealth index, maternal education, pre-gestational BMI.

† Logistic regression.

Hospitals Initiative, the creation of the Brazilian Network of Human Milk Banks and the implementation of 'Feed and Breastfeed Brazil Strategy' in order to encourage the population to adhere to the Brazilian dietary guidelines<sup>(5,28)</sup>. Additionally, Pelotas city hosted between 1997 and 1998 one of the participating centres of the WHO Multicentre Growth Reference Study in which health professionals from the municipality public health system were trained, and it was provided strong support to BF delivered at households by trained nurses. Consequently, there was an increment in the prevalence of EBF at 6 months of age, in 1993 was 0.5% and in 2015 was 14.5%<sup>(29)</sup>, but still below what would be ideal. A possible explanation for this phenomenon would be that maternal beliefs and insecurity of being offering fewer nutrients that the child needs could still be stronger in mothers of 2004c participants which leads to an earlier introduction of food compared with mothers of participants from 2015c. Additionally, mothers may still consider it normal to give fluids along with BF, as many babies have already received tea in the first month of life.

The factors that were associated with the early introduction of foods in the present study were also similar to those reported in other studies conducted in high-income countries<sup>(30-32)</sup>. Children with low birth weight (<2500 g), who were preterm (born before 37 weeks), were non-exclusive breast-fed for less than 6 months, and whose mother was young (<30 years old), lived without a partner, attended fewer than six antenatal care visits, were poorer, and had lower education level had higher early introduction of complementary feeding prevalence in both 2004c and 2015c. Additionally, only children from 2015c whose mothers had three or more children and were obese also presented higher early introduction of complementary feeding prevalence. It is possible that mothers of children who are small or premature at birth tend to overfeed them, as well as mothers with less information about child health.

Tea was the liquid food most introduced in both cohorts. It should be noted that in Brazil tea is a liquid food commonly introduced at an early age<sup>(33)</sup>. We believe that the widespread introduction of herbal tea in the first months of life is due to the belief in its medicinal functions. Exploratory analyses in our study showed that, in both cohorts, children who are given tea before 6 months of age, are also given other foods, including semi-solids and solids foods, before the age recommended by the WHO<sup>(4)</sup>. Introduction of herbal teas paired with other solid foods may be an issue, as recent research found that an early introduction of solids foods was associated with poor diet quality in childhood<sup>(27)</sup>.

In addition to the timing of the introduction of complementary feeding, the type of food introduced should be taken into account when exploring complementary feeding practices. Current guidelines recommend avoiding foods high in fat, salt or sugar and low in nutritional value in the first year of life. A high intake of foods such as sweet desserts, snack foods (e.g. chocolate, cookies and chips) and sugary beverages during infancy is associated with tooth decay, decline in the consumption of other nutritious foods, overweight/obesity and a high intake of these food types in later life<sup>(1,10,34,35)</sup>. Juice was introduced before the age of 3 months in half of the children and before the age of 12 months by 95.5% in 2004c and 87.8% in 2015c. Additionally,

almost 20.0 % of children in 2015c received soft drinks before the age of 12 months.

Powdered milk introduction prevalence before 12 months of age increased from 2004c to 2015c (from 31.5 to 53.1 %). Our data about powdered milk included infant formula and whole powder milk. Our hypothesis for this increment is because whenever BF is not possible, infant formula is recommended by paediatricians. Infant formula has a high protein content and has been shown to raise insulin secretions, the mechanism by which the adipocyte synthesis is promoted<sup>(36,37)</sup>.

The first 12 months of life are a critical time for children to experience food, flavours and textures. There is a growing evidence that healthy infant feeding practices have positive short- and long-term effects on child growth, body composition, neurodevelopment, healthy food preferences and gut microbiota composition and function<sup>(10,35)</sup>. Furthermore, adequate and healthy complementary foods may also diminish the risk of infections, allergies, coeliac disease, type 1 diabetes, as well as of non-communicable diseases<sup>(35)</sup>. Our study revealed an increase in introduction prevalence of vegetable and a reduction in dairy products (yogurt and porridge) before 12 months of age from 2004c to 2015c. It is possible that mothers are receiving better information about healthier child-feeding practices in primary health care units and through their paediatricians.

Early feeding introduction and risk of overweight at 24 months were associated in 2015c. The introduction of fresh milk or powdered milk plus liquids, semi-solids or solids increased the odds of risk of overweight at 24 months. The association was not observed in infants who were being breast-fed. One possible reason for this association among fresh milk or powdered milk consumers but not among breast-fed infants is that cows' milk and formula may increase their energy intake when liquids, semi-solids or solids are introduced. Formula-fed infants have, on average, a different feeding pattern from breast-fed infants, with a higher volume (total daily volume and per feed volume), lower frequency of feeds and longer time interval between feeds.

Another hypothesis for this association is that, regardless of the type of food offered to the child, early food introduction leads to higher energy consumption at a younger age. Breast milk, which is low in protein, may be displaced by complementary foods higher in energy and protein. Rapid weight gain during infancy is one of the strongest risk factors for later childhood obesity and also has been associated with increased blood pressure and diabetes incidence<sup>(2)</sup>. It is also possible that we only found an association between early complementary feeding practices and risk of overweight only in 2015c due to the significant increase over time in the introduction of powdered milk, that is, possibly formula-fed infants.

In Massachusetts, USA, a prospective pre-birth cohort study (Project Viva) which included 847 children found that among formula-fed infants, solid food introduction before 4 months of age was associated with a 6-fold increase in odds of obesity at 3 years old<sup>(12)</sup>. BF promotes self-regulation of energy intake in infants and enables the mother to learn and respond to infant's hunger and satiety signals, enabling mothers to feed their infant in the presence of hunger<sup>(37)</sup>.

Another longitudinal study, the Early Childhood Longitudinal Study -B, with a representative sample of over 10 000 children,

generalisable to American children born in 2001 examined the relation between infant-feeding practices and child obesity. Authors found that infants who were predominantly fed with formula for the first 6 months were about 2.5 times more likely to be obese at 24 months, compared with infants who were predominantly fed with breast milk, and that the early introduction of solid foods (before 4 months) increased the likelihood of obesity<sup>(38)</sup>.

Cross-sectional data from eight European countries found almost 40 % lower odds of childhood overweight/obesity (ages 2–9 years) in children who were introduced to solids right after 6 months of EBF and continued to receive breast milk ( $\geq 12$  months)<sup>(39)</sup>. A large population-based study from Australia with 3153 children found that early solid-food introduction (before 4 months) was associated with increased odds of above normal BMI at 1 year of age, regardless of child BF status at 4 months of age<sup>(40)</sup>.

It is crucial to detect the risk of being overweight at an early age (during the 1000 d) as it is a critical period of susceptibility where we can intervene in promoting the introduction of complementary foods accordingly to international recommendations and thus to prevent the risk of overweight at 24 months of age and, consequently, the development of overweight and obesity in childhood. Published evidence with 2004c participants showed that the overweight prevalence at 24 months of age was 8.3, and 12.3 % at 4 years old<sup>(41)</sup>, reinforcing the special attention that should be given in this age group since studies indicate that excess weight passes on to the next stages of life<sup>(42)</sup>.

In our study, we identified that approximately one-third of children were at risk of being overweight in 2004c and 2015c. Although 2015c boys displayed a higher prevalence of risk of overweight than 2015c girls, the odds of risk of overweight at 24 months was higher among 2015c girls who had an early food introduction. Our hypothesis is that the prevalence of risk of being overweight is higher in boys because they possibly consume greater amounts of food than girls, but the chance of presenting a risk of being overweight when introducing food early (before 6 months) is greater among girls due to the fact that girls in this age group spend less energy than boys, which would be contributing to the accumulation of body weight<sup>(43)</sup>.

### *Strengths and limitations*

In the present study, we examined longitudinal differences in complementary feeding practices during the first 12 months of age in two large birth cohort studies 11 years apart and with high follow-up rates. However, there are some methodological limitations to consider. In our data, we had a lack of information on sugar addition to liquids. Additionally, the age of introduction of water was only asked in the 3 months' follow-up in both 2004c and 2015c, and in consequence, we were not able to identify children who introduced water between 3 and 6 months of age (early feeding introduction). Soft drink introduction information was only available for 2015c and could not be included in the analyses because it was not asked in 2004c. However, this may not have affected our associations because all children who were introduced soft drinks before 6 months old in 2015c had already been introduced other foods before.



## Conclusions

Despite the small reduction in prevalence of early introduction of complementary foods from 2004c to 2015c, most children were introduced to foods earlier than recommended in both cohorts, especially children of mothers who were younger, less educated and poorest. In 2015c, early introduction of complementary foods was also associated with low birth weight, pre-term birth, children of mothers without partner, with three or more children, fewer than six prenatal visits and mothers with pre-pregnancy obesity. Early introduction was associated with an increased odds of risk of overweight at 24 months in the most contemporary cohort. Health system professionals should reinforce the adherence to global recommendations on timely feeding introduction and encourage EBF until 6 months of age, especially in a vulnerable population like ours with increasing rates of excessive weight gain in childhood<sup>(44)</sup>.

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