

# Consumption of foods with voluntary fortification of micronutrients in southern Brazil: prevalence and associated factors

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## Abstract

*Objective:* To investigate the consumption of foods with voluntary fortification of vitamins and minerals (FVFM) according to demographic, socio-economic and health characteristics.

*Design:* A cross-sectional population-based study.

*Setting:* The investigated food groups were selected in two stages according to availability of food in the local market and prevalence of food consumption in a recent national survey. The research instruments included a questionnaire and a photographic catalogue. The FVFM consumption covered a period of one week prior to the interview date. Statistical analyses were performed using Stata 12.0 statistical software package, considering the design effect and a hierarchical model. A multinomial logistic regression was applied to estimate the prevalence ratios. All tests were two-tailed, with a 5.0% significance level.

*Subjects:* Adults ( $\geq 20$  years old) living in a southern city of Brazil.

*Results:* Between February and June 2012, 2925 individuals were interviewed. Losses and refusals corresponded to 13.4% of the sample. The overall prevalence of FVFM consumption was 73.3 (95% CI 71.7, 75.9)%. The total number of FVFM reported exhibited a distribution with a median of two and a maximum of fifteen, inflated by the FVFM categorized in the 'juice' group. The micronutrients most consumed were vitamin C, followed by Fe and thiamin. Young adults, females, those of higher socio-economic status and those who perceived their health positively were more likely to consume FVFM.

*Conclusions:* Prevalence of FVFM consumption in southern Brazil, occurring concurrently with the decline in consumption of unprocessed and minimally processed foods, and the way voluntary fortification is being employed trigger a warning sign to primary prevention.

**Keywords**  
Cross-sectional studies  
Foods  
Fortified  
Micronutrients

Fortification is the addition of one or more nutrients to foods<sup>(1,2)</sup>, under levels established by the regulatory agency of each country<sup>(2)</sup>. In Brazil, according to the National Agency for Sanitary Vigilance, each 100 g or 100 ml of product ready for consumption must meet, respectively, a minimum level of 30% or 15% of the Recommended Daily Intake of a nutrient<sup>(3)</sup>.

When fortification is established by public policies or programmes, it is designated as 'mandatory' and should be implemented from epidemiological studies that corroborate the existence of risk population group(s) for a number of physiological and socio-economic reasons<sup>(2-4)</sup>. 'Voluntary' fortification ('market-driven' or 'discretionary'), in turn, is performed voluntarily; that is, private companies are allowed, but not required, to add nutrients to foods<sup>(4-6)</sup>. This mode is expanding and has evolved over time<sup>(1,7-9)</sup>, usually within regulatory limits<sup>(1)</sup>.

The increased consumption of foods with voluntary fortification has attracted the interest of researchers<sup>(5)</sup>, who are outlining ways to investigate how population levels of exposure to vitamins and minerals can be changed in the context of voluntary fortification. Part of these efforts has led to the demarcation of Tolerable Upper Intake Levels for micronutrients and related substances<sup>(5,6)</sup>; to raised evidence on long-latency subclinical deficiencies of micronutrients on the aetiology of chronic non-communicable diseases<sup>(10-12)</sup>, rather than the causal paradigm of nutritional disorders<sup>(10)</sup>; and to models based on 'risk assessment'.

Such models predict the attributable fraction for voluntary fortification in population levels of micronutrient intakes through the comparison of distribution curves<sup>(5-7,13-16)</sup>. The generated results – the potential benefits and drawbacks caused by such type of fortification – are not consensual in

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the literature and have incited wide discussion<sup>(17,18)</sup>. Legal measures concerning the advertising of foods have entered into this discussion as well, since voluntary fortification often occurs in processed and ultra-processed foods and has been characterized as a sophisticated sales strategy<sup>(19,20)</sup>, the effect of which is little known.

Thus, it becomes essential to answer a series of controversial and unexplored issues and to support a voluntary fortification based on scientific information<sup>(6,10)</sup>. The lack of publications, mostly in developing countries, reinforces the need to investigate the consumption patterns of foods with voluntary fortification of vitamins and minerals (FVFM). To provide a starting point, the present study aimed to estimate the prevalence of FVFM consumption according to demographic, socio-economic and health characteristics in the adult population of Pelotas, Brazil.

## Methods

Between February and June 2012, we carried out a cross-sectional population-based study in the urban zone of Pelotas, a southern Brazilian city populated by 328 000 inhabitants. The study was designed by a 'consortium' of students and professors, who developed their projects jointly. The study included individuals of both sexes, aged  $\geq 10$  years old, and excluded institutionalized individuals or those unable to answer interview questions.

The sample size for the present project was based on the following parameters: a 72% prevalence of FVFM (estimated in a pilot study); an acceptable error of 3.0 percentage points at 95% confidence level; a design effect of 2.0; and an increase of 10% to compensate for losses and refusals. Thus, the expected sample size ( $\geq 20$  years old) totalled 1885 individuals. To comply with the biggest required sample size (3712 individuals), we calculated a total of 1560 households considering an average of 2.38 people per household.

We conducted a random and systematic selection procedure to provide a multistage sampling, using data from the 'Census 2010' provided by the Brazilian Institute of Geography and Statistics. From 488 census tracts in the city, we selected 130 tracts to identify the households to be visited. In all selected census tracts, we performed a new count of households and then a proportional correction to the growth of households since 'Census 2010'. The households were classified according to occupancy status (residential, commercial or vacant). Only residential households were eligible. After this step, an average of twelve households per tract were selected.

For comparison reasons<sup>(9,21)</sup>, foods classified as 'source of' or 'fortified with' vitamins and/or minerals, by Brazilian legislation, were considered as 'FVFM'. We selected FVFM in two stages. Previously, we excluded fresh foods; foods regulated by the Brazilian Standard of Food Marketing for Children, Babyhood and Childcare Related

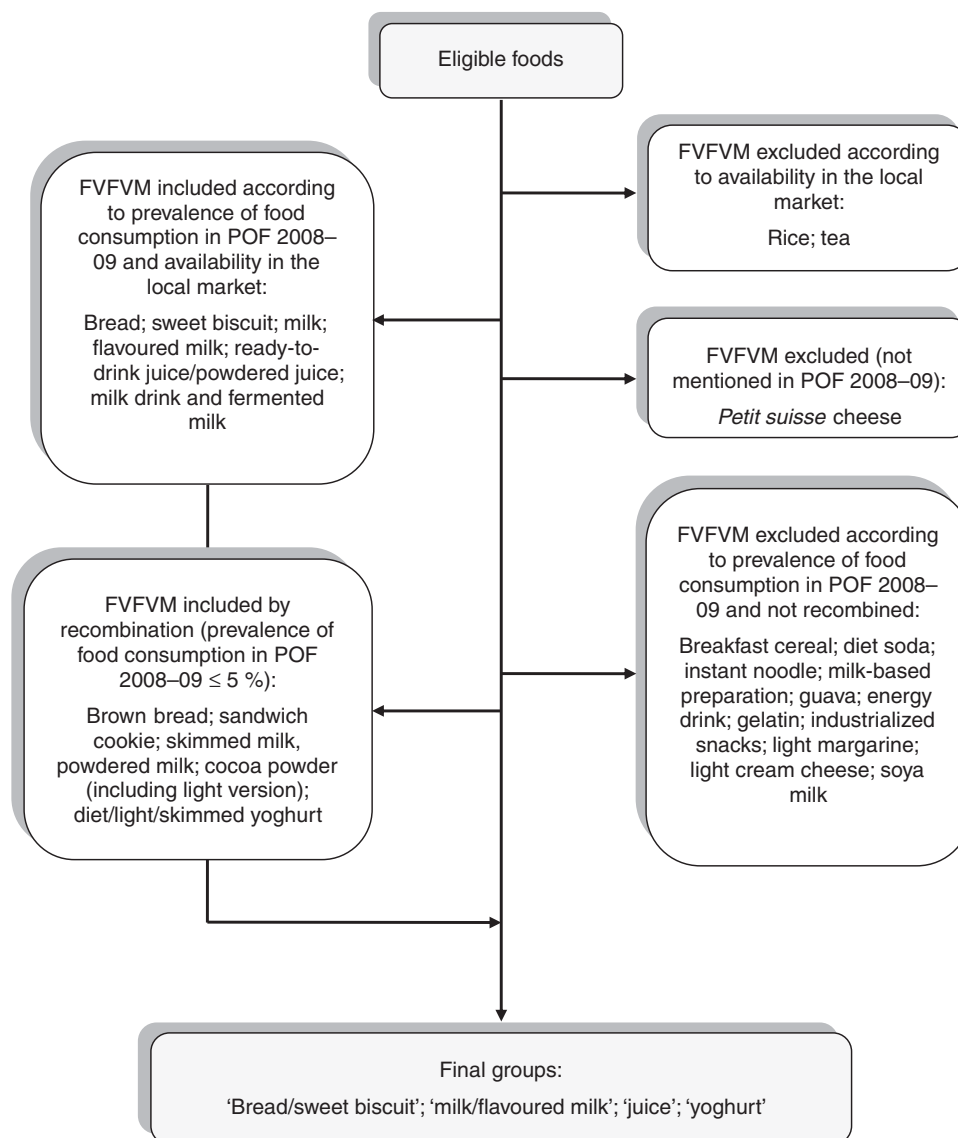
Products<sup>(22)</sup>; and compulsorily fortified foods<sup>(23)</sup>. In the first stage, from July 2011 to January 2012, all remaining (eligible) foods were checked in a monitoring survey conducted by the lead author through periodic visits to the six major supermarket chains of Pelotas, in order to collect FVFM according to technical standards<sup>(3)</sup>.

In the second stage, we referred to the section 'Analysis of Personal Food Consumption in south Brazil' from the latest Family Budget Survey 2008–09 (POF 2009–09)<sup>(24)</sup> to select which FVFM obtained in the monitoring survey would be integrated into the study. Two kinds of foods (with only one brand of FVFM, despite the wide number of available products) and one kind of food (not mentioned in POF 2008–09) were excluded. Then, those that showed a prevalence of consumption greater than 5%<sup>(5)</sup> according to POF 2008–09 were selected. To minimize the number of FVFM excluded, those showing similarities to the selected foods were merged. To simplify the process of choosing, foods were combined into four groups: 'bread/sweet biscuit', 'milk/flavoured milk', 'juice' and 'yoghurt'. Figure 1 shows a flowchart illustrating the process of composition of the final groups.

The questionnaire was pre-tested for comprehensibility and ease of completion. For each food group, a filter question about the consumption in the reference period was included with three response alternatives ('yes'; 'no'; 'I do not know/I do not remember'). In the case of an affirmative answer, the questionnaire went on to research the FVFM consumption, when a second instrument – a catalogue with photographs of fortified and non-fortified foods randomly arranged – was presented to the participant. The 'bread/sweet biscuit' group contained forty-eight photos in the ratio 25:23 (1.09), i.e. twenty-five photos of FVFM and twenty-three photos of non-fortified foods. In the 'milk/flavoured milk' group there were sixty-one photos in the ratio 37:24 (1.54). The 'juice' group contained forty-seven photos in the ratio 32:15 (2.13), while the 'yoghurt' group totalled thirty photos in the ratio 18:12 (1.50).

Before presenting the photographic catalogue, the participant was asked to 'point to' photos corresponding to the consumed foods. A number in the footer of each photo pointed to was recorded by the interviewer. The decoding of these numbers, accessible only to the authors, allowed identifying foods with and without fortification. Participants who reported consumption of one or more FVFM belonging to any food group, within a week prior to the interview date, were positive for the outcome 'FVFM consumption'. Participants who reported impaired visual acuity, could not answer precisely, reported difficulty recalling and reported consumption of non-catalogued foods had their answers classified with a code for each situation.

We investigated the following characteristics of participants: sex, age (in complete years), self-perceived skin colour (according to the Brazilian Institute of Geography



**Fig. 1** Composition of the food groups investigated. Pelotas, Brazil, 2012 (FVFVM, foods with voluntary fortification of vitamins and minerals; POF 2009–09, Family Budget Survey 2008–09)

and Statistics classification; the categories 'yellow' and 'indigenous' were merged into 'others'), current marital status (married/with partner; single/without partner; separated; widowed), schooling (in complete years), household income (according to the Brazilian Institute of Geography and Statistics concept) and self-rated health (excellent; very good; good; regular; bad). In the hierarchical model, demographic variables (gender, skin colour and age) and socio-economic variables (marital status, schooling and family income) were used in the first level of determination. In the second level, self-rated health was used.

All data were collected by trained interviewers using a netbook (Samsung C&T Corporation Bldg, Seocho-Gu Seoul, South Korea). The database was created using the Pendragon Forms 6.0 software. Amplitude and consistency

checks were conducted to search for errors during the fieldwork. Quality control was conducted by revisits to nearly 10% of participants, randomly selected. For that purpose we applied a reduced questionnaire to identify possible errors or false answers and, thereafter, to evaluate the agreement and repeatability.

Statistical analyses were performed with the Stata 12.0 statistical software package according to the sampling design and a hierarchical model, as previously mentioned. Prevalence of dichotomized 'FVFVM consumption' and the 95% confidence interval were calculated. Multinomial logistic regression was used to estimate prevalence ratios (PR) and their 95% confidence intervals as the measure effect between 'number of consumed FVFVM' (in quartiles) and independent variables, by a specific command for PR.

Wald tests for heterogeneity and for linear trend were applied to assess differences between groups. All tests were two-tailed, with a significance level of 5%.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Research Ethics Committee of the Faculty of Medicine of the Federal University of Pelotas. Written informed consent was obtained from all participants.

## Results

Among the 1722 households selected, we identified 3379 adults who met the inclusion criteria. The final sample comprised 1555 households and 2925 respondents interviewed between February and June 2012. The 'non-respondents' were, on average, 45.8 (sd 17.4) years old, ranging between 20 and 88 years, constituting 13.4% of the sample (454 individuals), with a large proportion of men (56.4%).

The quality control was applied to 285 participants (9.7% of the sample) and two questions about education were

repeated: 'be able to read and write' ('yes'; 'no'; 'I can only sign my name') and 'schooling' (in complete years). The agreement in 'schooling' was considered 'good' ( $\kappa = 0.83$ ). The intra-class correlation coefficient was 0.03, and the design effect was 1.73 for the dichotomous outcome.

We identified and excluded from analysis eight participants with blindness or severe impairment of visual acuity, and fifty-seven who could not answer precisely or were unable to report or reported difficulty recalling, at some point in the interview, which group(s) or product(s) they had consumed. The excluded participants differed from those who were included in terms of age (40% were  $\geq 60$  years), marital status (20% were widowed), schooling (33.8% with a maximum of four complete years and 12.3% with twelve complete years or more) and self-rated health (49.2% rated their health as regular or bad). Table 1 describes the analysed sample (2860 participants) – with an average age of 45.5 (sd 16.5) years, ranging between 20 and 95 years – and the prevalence of dichotomized FVFM consumption.

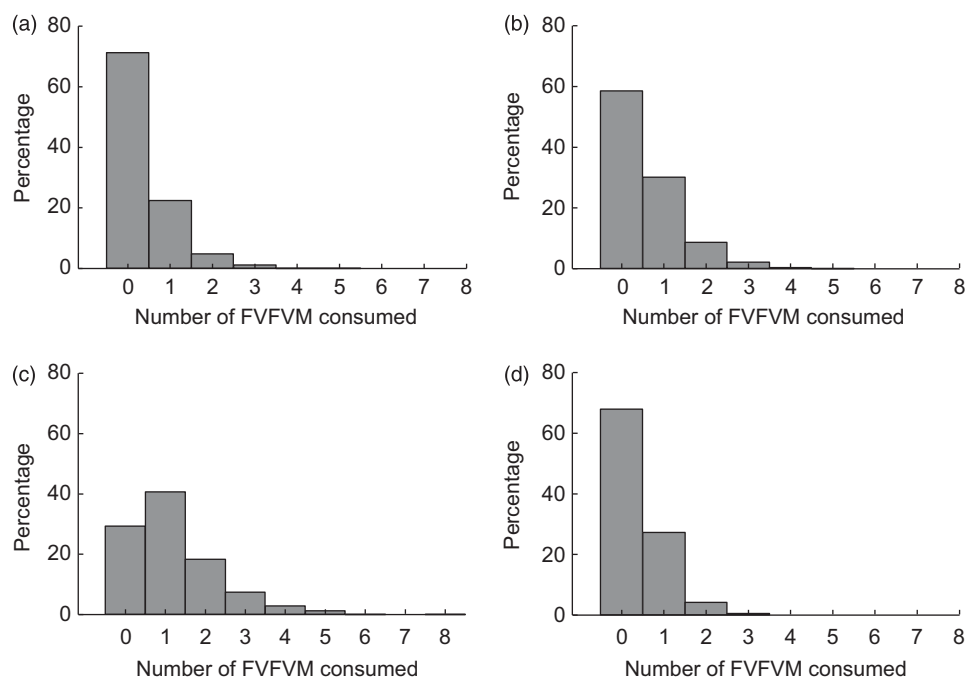
Figure 2 shows the distribution of FVFM consumption in each food group. It was observed that 88.7% of participants answered affirmatively to the filter question for the

**Table 1** Sample description and prevalence of FVFM consumption according to demographic, socio-economic and health variables (*n* 2860). Pelotas, Brazil, 2012

Variable	<i>n</i>	%	Prevalence (%)	95% CI
Sex				
Male	1178	41.2	72.1	69.3, 75.0
Female	1628	58.8	75.0	72.7, 77.3
Skin colour				
White	2290	80.1	73.0	70.6, 75.4
Black	346	12.1	78.9	73.7, 84.1
Mestizo	189	6.6	74.6	68.6, 80.6
Others	34	1.2	73.5	60.1, 87.0
Age (complete years)				
20–29	605	21.1	88.4	85.6, 91.2
30–39	534	18.7	82.7	79.1, 86.4
40–49	580	20.3	76.5	73.0, 80.1
50–59	502	17.6	64.9	60.5, 69.4
$\geq 60$	639	22.3	56.9	52.9, 61.0
Marital status				
Married/with partner	1734	59.4	73.1	70.4, 75.7
Single/without partner	714	24.4	77.8	73.7, 81.8
Separated	232	7.9	79.1	73.5, 84.7
Widowed	241	8.3	62.3	55.2, 69.3
Schooling (complete years)				
0–4	502	17.5	61.3	57.0, 65.8
5–8	802	28.1	70.9	67.2, 74.7
9–11	799	28.0	80.2	77.0, 83.4
$\geq 12$	754	26.4	78.5	74.8, 82.2
Family income (tertile)				
Lower	931	33.7	70.1	66.4, 73.9
Middle	918	33.2	74.2	70.6, 77.7
Higher	916	33.1	77.3	74.1, 80.4
Self-rated health				
Excellent	380	13.3	85.0	81.5, 88.5
Very good	507	17.7	77.7	73.5, 82.0
Good	1212	42.4	74.0	71.3, 77.3
Regular	633	22.1	65.2	61.4, 69.1
Bad	128	4.5	60.7	54.6, 70.4

FVFM, foods with voluntary fortification of vitamins and minerals.

Family income was the variable with the largest number of missing values (*n* 65), equivalent to 3.25%. The other variables had at most four values missing.



**Fig. 2** Distribution of FVFVM consumption for each food group investigated: (a) 'bread/sweet biscuit'; (b) 'milk/flavoured milk'; (c) 'juice'; (d) 'yoghurt'. Pelotas, Brazil, 2012 (FVFVM, foods with voluntary fortification of vitamins and minerals)

group 'bread/sweet biscuit'. Among these, FVFVM consumption was observed in 28.7 (95% CI 26.3, 31.1) % and there were mentions of one FVFVM up to a maximum of five products. The prevalence of consumption in the group 'milk/flavoured milk' was 52.1%, of whom 41.5 (95% CI 38.5, 44.1) % consumed FVFVM, varying from one to five products. Of the participants 50.3% reported consumption in the group 'juice', of whom 70.7 (95% CI 67.6, 73.8) % consumed FVFVM, but the amplitude was higher, ranging from one to eight products. In the group 'yoghurt', 32.6% of participants reported consumption of such food, of whom 32.1 (95% CI 28.8, 35.4) % consumed FVFVM, ranging from one to three products.

Throughout the interview, 73.8 (95% CI 71.7, 75.9) % of the participants reported consumption of one FVFVM at least. This distribution exhibited a median of two and a maximum of fifteen FVFVM and was inflated by the 'juice' group. In all food groups, more non-fortified foods were selected by the participants; considering the opposite ratios found among the reported foods with or without fortification, the ratio was 0.45 in the 'bread/sweet biscuit' group, 0.51 in the 'milk/flavoured milk' group, 0.88 in the 'juice' group and 0.42 in the 'yoghurt' group.

The results for FVFVM consumption in quartiles are summarized in Tables 2 and 3. After adjustment, the difference between the sexes was marked in the fourth quartile, where women were 1.63 times more likely to have higher FVFVM consumption than men. The association with skin colour was observed only in the fourth quartile of the adjusted analysis, where participants of

black skin colour showed almost two times higher prevalence of FVFVM consumption than white participants. In both crude and adjusted analyses, the differences among age groups increased progressively from quartile 1 to quartile 4 of consumption, with a maximum gradient in the age group of 20–29 years compared with the reference group of  $\geq 60$  years. Concerning marital status, there was strong association in the adjusted analysis only for quartile 3, where the single participants were less likely to consume FVFVM compared with the reference group of widowed.

The schooling variable was not associated after adjustment, except for the fourth quartile, where participants with better education (nine complete years or more) were almost two times more likely to present greater FVFVM consumption than the reference group (up to four complete years). The association observed for both household income and self-rated health in the crude analysis was maintained in the adjusted analysis only until the third quartile, where participants with higher family incomes (compared with lower) and who perceived their health positively (compared with 'bad') were more likely to present a higher FVFVM consumption.

Table 4 shows the rank of added micronutrients and their respective fortification levels, based on the total of FVFVM reported (consumed) by participants and summarized as median and interquartile range. Vitamin C leads the rank with 3131 references to products that contain this vitamin, followed by Fe (2225) and thiamin (2046). The list ends with biotin (596), vitamin E (409) and Zn (371).

**Table 2** Crude multinomial analysis of FVFVM consumption according to hierarchical model (*n* 2860). Pelotas, Brazil, 2012

Variable	Quartile 2 (1 FVFVM)			Quartile 3 (2–3 FVFVM)			Quartile 4 ( $\geq 4$ FVFVM)		
	PR	95% CI	<i>P</i> value	PR	95% CI	<i>P</i> value	PR	95% CI	<i>P</i> value
Level 1									
Sex			0.19*			0.38*			<0.01*
Male	1.00	–		1.00	–		1.00	–	
Female	1.12	0.94, 1.35		1.08	0.91, 1.27		1.42	1.15, 1.74	
Skin colour			0.45*			0.24*			0.13*
White	1.00	–		1.00	–		1.00	–	
Black	1.26	0.88, 1.80		1.39	0.97, 2.00		1.61	1.06, 2.46	
Mestizo	0.87	0.58, 1.28		1.24	0.85, 1.82		1.19	0.73, 1.93	
Others	0.97	0.42, 2.23		0.78	0.27, 2.26		1.69	0.70, 4.06	
Age (complete years)			<0.01†			<0.001†			<0.001†
20–29	2.60	1.85, 3.66		7.29	5.06, 10.5		18.49	11.49, 29.75	
30–39	2.00	1.43, 2.78		4.56	3.21, 6.49		9.58	6.04, 15.19	
40–49	1.50	1.12, 2.02		3.15	2.30, 4.30		5.47	3.38, 8.85	
50–59	1.37	1.07, 1.77		1.43	1.05, 1.94		1.42	0.83, 2.45	
$\geq 60$	1.00	–		1.00	–		1.00	–	
Marital status			0.10*			<0.001*			<0.001*
Married/with partner	1.20	0.84, 1.72		1.86	1.26, 2.73		3.07	1.61, 5.86	
Single/without partner	1.24	0.78, 1.95		2.47	1.60, 3.81		5.21	2.82, 9.65	
Separated	1.79	1.13, 2.84		2.80	1.71, 4.59		2.99	1.39, 6.41	
Widowed	1.00	–		1.00	–		1.00	–	
Schooling (complete years)			<0.001†			<0.01†			<0.001†
0–4	1.00	–		1.00	–		1.00	–	
5–8	1.10	0.84, 1.44		1.77	1.30, 2.39		2.76	1.79, 4.25	
9–11	1.85	1.34, 2.55		2.72	1.94, 3.83		5.29	3.32, 8.45	
$\geq 12$	1.58	1.15, 2.18		2.34	1.64, 3.32		5.61	3.45, 9.13	
Family income (tertile)			0.02*			0.07*			0.09*
Lower	1.00	–		1.00	–		1.00	–	
Middle	1.28	0.98, 1.68		1.17	0.87, 1.60		1.22	0.83, 1.78	
Higher	1.47	1.12, 1.92		1.41	1.05, 1.88		1.50	1.05, 2.15	
Level 2									
Self-rated health			<0.001†			<0.001†			<0.001†
Excellent	2.22	1.34, 3.67		4.03	2.44, 6.65		5.89	2.71, 12.83	
Very good	1.50	0.91, 2.47		2.22	1.33, 3.69		3.95	1.94, 8.04	
Good	1.40	0.90, 2.17		1.83	1.18, 2.83		2.73	1.40, 5.33	
Regular	0.98	0.62, 1.55		1.13	0.70, 1.82		1.66	0.87, 3.14	
Bad	1.00	–		1.00	–		1.00	–	

FVFVM, foods with voluntary fortification of vitamins and minerals; PR, prevalence ratio.

The first quartile (0 FVFVM) is the base outcome and was omitted.

\*Wald test for heterogeneity.

†Wald test for linear trend.

Iodine, Mn and P represented an insignificant total amount of references (<1% of the sample) and were omitted.

## Discussion

Most associations, reported by studies using heterogeneous methodologies, were analysed at different levels of FVFVM consumption and corroborated in the present study. The methodological rigour and data collection, continued for long enough to identify seasonal effects<sup>(5)</sup>, stand out as the main advantages of the present study. Given that respondents tend to present a better remembrance of their frequency of consumption when presented with a short list of specific items<sup>(5)</sup>, the focus on four food groups allowed the minimization of 'recall bias'. In addition, the photographic catalogue allowed us to circumvent the difficulty in assessing FVFVM consumption by conventional methods<sup>(6,8)</sup> and this strategy does not seem to influence

the responses, since the rates found among foods with and without fortification were contrary to the rates established for this instrument.

Due to exclusion of other FVFVM in the study, the overall prevalence of FVFVM consumption should be taken as an underestimated measure and the outcome 'number of FVFVM', divided into quartiles, as a limited measure for intensity of consumption; larger or smaller portions can be ingested, regardless the number and type of FVFVM reported.

Considering that foods have expanded from goods produced and traded in an essentially local level to a global level<sup>(25)</sup>, the present results probably demonstrate a similar phenomenon to that in countries where fortification is allowed. However, the results reflect some aspects of the local production and trade, and the extrapolation of findings to other populations should be done with caution. Newer versions of FVFVM, with different combinations of micronutrients, are routinely introduced

**Table 3** Adjusted multinomial analysis of FVFVM consumption according to hierarchical model (*n* 2860). Pelotas, Brazil, 2012

Variable	Quartile 2 (1 FVFVM)			Quartile 3 (2–3 FVFVM)			Quartile 4 (≥4 FVFVM)		
	PR	95% CI	<i>P</i> value	PR	95% CI	<i>P</i> value	PR	95% CI	<i>P</i> value
<b>Level 1</b>									
Sex			0.17*			0.11*			<0.001*
Male	1.00	–		1.00	–		1.00	–	
Female	1.15	0.94, 1.40		1.16	0.96, 1.40		1.63	1.30, 2.03	
Skin colour			0.27*			0.22*			0.03*
White	1.00	–		1.00	–		1.00	–	
Black	1.42	0.98, 2.04		1.46	1.00, 2.12		1.84	1.18, 2.87	
Mestizo	0.95	0.62, 1.46		1.27	0.84, 1.93		1.30	0.79, 2.16	
Others	1.23	0.51, 2.95		0.93	0.30, 2.90		2.13	0.80, 5.65	
Age (complete years)			<0.001†			<0.001†			<0.001†
20–29	3.00	2.07, 4.36		9.05	5.76, 14.20		16.86	9.70, 29.30	
30–39	2.19	1.56, 3.07		4.99	3.44, 7.24		8.49	5.13, 14.05	
40–49	1.53	1.09, 2.14		3.30	2.33, 4.68		4.78	2.87, 7.98	
50–59	1.43	1.09, 1.88		1.46	1.03, 2.06		1.24	0.70, 2.19	
≥60	1.00	–		1.00	–		1.00	–	
Marital status			0.02*			<0.001*			0.12*
Married/with partner	0.85	0.54, 1.32		0.73	0.47, 1.14		0.82	0.41, 1.61	
Single/without partner	0.65	0.38, 1.12		0.57	0.34, 0.95		0.60	0.30, 1.21	
Separated	1.48	0.87, 2.51		1.58	0.91, 2.73		1.18	0.50, 2.82	
Widowed	1.00	–		1.00	–		1.00	–	
Schooling (complete years)			0.13*			0.29*			0.05*
0–4	1.00	–		1.00	–		1.00	–	
5–8	0.89	0.66, 1.20		1.17	0.85, 1.62		1.60	1.00, 2.55	
9–11	1.25	0.87, 1.78		1.31	0.92, 1.87		2.04	1.23, 3.37	
≥12	1.00	0.67, 1.48		0.97	0.64, 1.47		1.98	1.11, 3.53	
Family income (tertile)			0.05*			0.05†			0.22*
Lower	1.00	–		1.00	–		1.00	–	
Middle	1.25	0.94, 1.66		1.15	0.85, 1.55		1.09	0.73, 1.62	
Higher	1.50	1.08, 2.09		1.62	1.15, 2.27		1.41	0.93, 2.14	
<b>Level 2</b>									
Self-rated health			0.02†			<0.01†			0.19*
Excellent	1.61	0.93, 2.79		2.01	1.10, 3.64		1.81	0.75, 4.38	
Very good	1.02	0.60, 1.74		1.09	0.60, 1.97		1.24	0.56, 2.78	
Good	1.05	0.67, 1.65		1.08	0.67, 1.74		1.07	0.51, 2.21	
Regular	0.83	0.52, 1.33		0.90	0.53, 1.52		1.15	0.57, 2.29	
Bad	1.00	–		1.00	–		1.00	–	

FVFVM, foods with voluntary fortification of vitamins and minerals; PR, prevalence ratio.

The first quartile (0 FVFVM) is the base outcome and was omitted.

\*Wald test for heterogeneity.

†Wald test for linear trend.

**Table 4** Rank of vitamins and minerals added and their fortification levels according to FVFVM consumed. Pelotas, Brazil, 2012

Rank	Micronutrient	Median of FL (%)	Interquartile range of FL (%)
1	Vitamin C	7.7	7.5–15.5
2	Fe	8.0	7.5–9.5
3	Thiamin	16.0	15.5–16.0
4	Vitamin A	11.5	7.5–19.0
5	Riboflavin	16.0	9.0–19.0
6	Ca	16.0	8.9–22.0
7	Vitamin B <sub>6</sub>	16.0	9.0–20.0
8	Niacin	16.0	9.5–19.0
9	Vitamin B <sub>12</sub>	16.0	16.0–20.0
10	Pantothenic acid	16.0	9.5–16.0
11	Vitamin D	20.0	9.4–30.0
12	Folic acid	9.5	7.5–20.0
13	Mg	6.1	6.1–6.1
14	Biotin	16.0	16.0–16.0
15	Vitamin E	20.0	7.5–32.0
16	Zn	19.0	7.5–20.0

FVFVM, foods with voluntary fortification of vitamins and minerals; FL, fortification level.

Iodine, Mn and P represented an insignificant amount of references (&lt;1% of the sample) and were omitted.

on the market. As a result, the nutritional composition of these products can easily become out of date<sup>(5,6,10,17)</sup>. Changes in regulatory framework may also affect the composition and nutritional bioavailability of FVFVM, impeding extemporaneous comparisons<sup>(5)</sup>.

Regarding the food groups, we found similarities with a Finnish study. Its authors used an FFQ of 48 h and a shopping diary of 5 d, identifying FVFVM by barcode. The groups 'yoghurt' and 'juice' figured in the rank of food groups with the highest amount of FVFVM consumed<sup>(8)</sup>. These groups also emerged in other studies, along with the groups 'milk'<sup>(18)</sup>, 'bread'<sup>(17)</sup> and 'sweet biscuit'<sup>(26)</sup>.

In Belgium, it was observed that 66.7% of the population consumed soya-based products fortified with Ca daily or almost daily. Assessing daily consumption of these products through a self-administered FFQ for two consecutive days, a more frequent consumption in women than in men and a higher average intake in the younger age group were found<sup>(27)</sup>. In the Finnish study already mentioned, younger participants showed higher FVFVM consumption<sup>(8)</sup>. Although the foods surveyed in Belgium are recommended in their guidelines, and the trade of FVFVM in Finland has been allowed in the same year of data collection, the findings of these and other studies<sup>(17,28)</sup> align with the results of the present study, with a higher probability of FVFVM consumption in women and young adults.

Participants with white skin colour were less likely to consume FVFVM, the opposite of the authors' hypothesis. Although most studies do not indicate a large difference among categories of marital status for FVFVM consumption, there are still few studies in the literature exploring this kind of association. The findings for single participants suggest that such differences could be better investigated using other approaches in larger samples.

In Ireland, adults with diets and lifestyles considered more healthy presented a higher FVFVM consumption, which was considered a marker of best dietary patterns<sup>(17)</sup>. In Finland, there was an opposite direction, indicating a weak or absent association for most factors related to lifestyle, such as physical activity, not smoking, use of dietary supplements and low alcohol consumption<sup>(8)</sup>. In Canada, an association with low micronutrient intake, low dietary quality and an inverse association for fruit and vegetable intake has been demonstrated<sup>(29)</sup>, although the last finding is not consistent in the literature<sup>(8,17)</sup>.

It is worth mentioning that the consumption of powdered or 'ready-to-drink' juices, examined in the present study, was related to higher average consumption of sugar in POF 2008–09<sup>(24)</sup>. The consumption of 'sandwich cookie', included in the group 'bread/sweet biscuit', was pointed out as one of the most important markers of an unhealthy diet, associated with reduced intakes of micronutrients and high energy consumption, particularly from saturated fat and sugar<sup>(24)</sup>. Thus, voluntary fortification could stimulate the consumption of these products<sup>(1)</sup>, rather than better food choices<sup>(29)</sup>.

In the Finnish study, schooling was not an independent determinant, although the authors concluded that in larger samples such a variable may present a positive association<sup>(8)</sup>. In the present study, the change of effect observed for schooling over the quartiles suggest that this relationship may be true for individuals who consume more FVFVM<sup>(17)</sup>. So, it seems not possible to rule out that food selection is partly mediated by fortification itself, and partly by other attributes, such as availability and access<sup>(1,8,17)</sup>.

In the present study, the variable that summarizes general health showed a strong association with FVFVM consumption, especially in the group who perceived their health as 'excellent'. In a Polish study, there was no statistically significant correlation between subjective evaluation of health status and FVFVM consumption<sup>(28)</sup>. It should be emphasized that due to simultaneous collection of variables, the results in the two studies do not necessarily reflect a causal relationship.

Although there is a growing body of evidence about the positive effects of mandatory fortification for certain micronutrients, some researchers consider it premature to extrapolate these inferences for voluntary fortification<sup>(6)</sup>. Such prudence is based on a potential sub- and over-fortification<sup>(5,7)</sup>, or an imbalance in the metabolism of other nutrients<sup>(2)</sup>. Hence, there are proposals requesting the voluntary fortification – as well as the mandatory fortification – to be scientifically justified, periodically reviewed and monitored by criteria that limit the indiscriminate addition of nutrients to foods<sup>(1,6,21,30)</sup>. As the consumption pattern of these foods cannot be controlled, both mandatory and voluntary fortification should have a careful formulation<sup>(5)</sup>.

There are also ethical implications involving the regulation of voluntary fortification<sup>(7,20)</sup>. Allegations employed in FVFVM for marketing purposes<sup>(4,5,13)</sup> convey indirectly the message that these foods contribute substantially to the 'welfare' of individuals who consume them<sup>(4,6,28)</sup>. Since there is a common concern among consumers that typical diets are unlikely to provide adequate amounts of vitamins and minerals<sup>(10)</sup>, the claims cannot induce a misinterpretation about the nutritional value of foods<sup>(2)</sup>.

The importance of micronutrients on functional capacity and longevity, with a potential impact on reducing health costs, has made food fortification a strategy widely adopted for prevention and control of nutritional deficiencies<sup>(4,6,31)</sup>. In Brazil, the high prevalence of inadequate micronutrient intakes reaches all major regions and reflects the low quality of the Brazilian diet, provoking a greater susceptibility to nutritional deficits<sup>(24)</sup>. However, the way voluntary fortification is being employed does not meet the precautionary principle discussed in the main guidelines, and many FVFVM do not offer a nutritional equivalence compared with natural sources, a critical issue in the prevailing context of replacement of traditional foods for processed and ultra-processed food products<sup>(1,24)</sup>. Furthermore, it was observed that several products are fortified with Fe, folic



acid and vitamin A. The first two micronutrients are both targets of Brazilian mandatory fortification, whereas the third is a target of supplementation. This implies a superposition of initiatives, requiring a regulatory review established between government and industry.

The present study is the first population-based cross-sectional one that provides an overview about the topic in Brazil. It brings aids to generate hypotheses and prompt larger and more complex studies. Most of the consumed FVFM contain a potential and substantial contribution to the average daily micronutrient intake of individuals. The groups with higher socio-economic level were evidenced as the most likely to consume FVFM, emphasizing the need to investigate to what extent these groups may have been benefited or not by this additional exposure of micronutrients. Moreover, the observed prevalence of FVFM consumption, occurring concurrently with the decline in consumption of unprocessed and minimally processed foods, triggers a warning sign to primary prevention. If the market expansion of FVFM continues, this practice could also accelerate the time trends of dietary patterns, increasing unfavourable outcomes for health as a consequence.

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