Sugar and total energy content of household food purchases in Brazil

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Abstract

Objective: To study the role of energy derived from sugar (both table sugar and sugar added to processed foods) in the total energy content of food purchases in Brazil.

Design: Food purchase data were collected during a national household budget survey carried out between June 2002 and July 2003 on a probabilistic sample representative of all households in the country. The amount of food purchased in this 12-month period was transformed into energy and energy from sugar using food composition tables. Multiple linear regression models were used to study the association between amount of energy from sugar and total energy content of food purchases, controlling for sociodemographic variables and potential interactions between these variables and sugar purchases.

Results: There was a positive and significant association between energy from sugar and total household energy purchases. A 1 kJ increase in sugar purchase corresponded to a 3·637 kJ increase in total energy. In the absence of expenditure on meals outside the home, i.e. when household food purchases tend to approximate actual food consumption by household members, sugar purchase of 1926·35 kJ/d (the 90th percentile of the distribution of sugar purchases in Brazil) was associated, depending on income strata, with total energy purchase over 40–60 % of the recommended daily value for energy intake in Brazil.

Conclusions: The present results corroborate the recommendations of the WHO and the Brazilian Ministry of Health regarding limiting the consumption of sugar.

Demographic and economic changes are accelerating across the globe, and particularly in developing countries. Such changes have an especially marked effect on diet composition. Noteworthy among these effects is the increased consumption of sugar (both table sugar and sugar added by the processed food industry) and fat, along with the decrease in consumption of complex carbohydrates[1]. An analysis of global food availability showed that the per capita availability of sugar increased by 32 % between 1962 and 2000 (corresponding to a daily increase of 315 kJ). Urbanization and increased income are thought to account for 82 % of the increase in sugar intake, the remainder being attributed to factors related to changes in consumer behaviour and/or expansion of the food industry[2]. In the USA, per capita sugar intake among the population older than 2 years of age increased by 349 kJ/d between 1977 and 2000, which raised by 22 % the contribution of sugar to the total energy content of the diet in this population (from 13·0 % to 15·8 %). Of this

increase, 227 kJ corresponded to soft drinks and 55 kJ to sweetened fruit juice. Among adolescents, there was an increase in the intake of soft drinks at the expense of milk[2].

Brazil is the biggest sugar producer in the world, with an annual production of 26·4 million tonnes (raw sugar equivalent) in 2003. In this same year, the per capita availability of sugar in Brazil was 2310 kJ/d, which corresponded to 17·5 % of total energy available for consumption. This high contribution of sugar to the total food supply, one of the highest in the world, has remained almost unchanged since the early 1960s[3].

The potential health hazards associated with increased sugar intake and the maximum limits for its contribution to the diet have been the object of intense debate in national and international forums[1,4,5]. The WHO and the FAO claim there is convincing evidence that excessive sugar intake increases the risk of at least two important public health problems: obesity (via increased energy intake) and dental caries. Based on this evidence, these

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agencies recommend that the contribution of sugar not exceed 10 % of total energy in a diet[1]. On the other hand, the Institute of Medicine, a non-governmental organization responsible for elaborating dietary guidelines for the American and Canadian populations, believes the dilution of micronutrients to be the only proven negative effect of sugar intake, and that this effect can only be felt when the contribution of sugar in the diet exceeds 25 % of total energy intake[5].

Sugar intake can influence total energy intake through hedonic and physiological mechanisms. Owing to its organoleptic properties, sugar intake triggers a strong sensation of pleasure[6]. In physiological terms, the ingestion of sugar leads to a rapid increase in blood glucose, which is followed by the release of high amounts of insulin, leading to the reduction of blood glucose to levels below normal. Low blood glucose leads to a feeling of hunger, and thus may result in excessive energy intake[7]. Furthermore, high sugar content may lead to highly energy-dense diets, which once more can give rise to excessive energy intake[8,9]. Other studies suggest that ingestion of sweetened beverages increases the total energy content of the diet by limiting appetite-control mechanisms and provoking a reduction in the compensatory effect of food intake[10–13].

Population-based studies on the effects of sugar intake on total energy intake are scarce and usually are restricted to developed countries[2,14]. The present paper uses data from a national household budget survey conducted in Brazil in 2002–3 to study the role of energy derived from sugar (both table sugar and sugar added to processed foods) in the total energy content of food purchases in Brazil.

Methods

All data analysed in the current study originate from the Household Budget Survey carried out by the Brazilian Institute of Geography and Statistics between June 2002 and July 2003 (2002–3 HBS) using a representative sample of all Brazilian households. As explained below, the data collected in this survey describe in great detail all food purchases made by families throughout a 12-month period, thus providing simultaneous estimates for the two variables that we shall attempt to correlate: energy from sugar and total energy content of food purchases.

Sampling
The 2002–3 HBS was designed so as to represent the totality of Brazilian households and urban or rural households from each of the twenty-six Brazilian states. This sample was stratified and randomized in two stages. The 443 sample strata were formed by grouping census tracts homogeneous with respect to territorial domain (states), urban or rural settings and average household socio-economic characteristics. Selection of census tracts

(primary sampling unit) within each stratum was done by systematic sampling with probability proportional to the number of households in the tract. Household selection (secondary sampling unit) within each sector was done by simple random selection without reposition. In order for data collection to be uniform throughout the year's four trimesters, interviews carried out within each of the 443 strata were distributed throughout the 12 months of survey. From 60 911 households selected in 3984 tracts, a total of 48 470, or 79·6 %, were effectively investigated.

The reference period for collecting information on food purchases in individual households in the 2002–3 HBS was only 7 d. As such a short reference period does not allow for an adequate characterization of the food purchasing patterns of each household, the unit of analysis in the present study is the set of studied households in each of the sample's 443 strata, rather than the individual household. The mean number of households in each of these strata was 109·6, ranging from 9 to 804. The weighting factor for each stratum was defined as the sum of the weighting factors of all households included in the stratum.

Data collection
Information on food items purchased by each household was obtained using the survey's collective expense notebook. In this notebook, household members recorded all food purchases made during seven consecutive days, including amount, purchase unit with its equivalent weight or volume, amount paid, place of purchase, and how the food was obtained. In about 75 % of households, daily purchase data recorded in the notebook were registered electronically by the survey interviewer using a portable computer, thus allowing for information consistency to be verified and errors to be corrected while still in the household.

Variable construction
The central variables in the present study are total energy purchased by the households in each of the survey's strata and the energy derived from sugar. In the latter case, we considered both table sugar and sugar added by the processed food industry. Rapadura (hardened sugar cane extract), molasses, honey and other caloric sweeteners, even though accounting for a minute fraction of the total energy purchased by Brazilian families, were also considered in the calculation of energy from sugar. Intrinsic sugar present in food, such as fructose and sucrose in fruits, was regarded as part of the remaining energy not provided by sugar. The procedures employed for obtaining these variables were as follows: (i) addition of the amounts of the same food (in grams) purchased in the 7 d period; (ii) use of a correction factor for each food type that considers only its edible portion[15]; (iii) conversion of the purchased amount of each food into total energy and energy from sugar, using the TACO chart

(Brazilian Food Composition Table)[16] or the US official food composition table version 15[17] for the few items not present in TACO. In the specific case of conversion to energy from sugar, calculation was done in two stages: conversion of quantities (in grams) into energy from carbohydrates (using TACO whenever possible) and conversion of energy from carbohydrates into energy from sugar (using the American chart, as TACO does not specify the types of carbohydrates in each food); and (iv) addition of total energy and energy from sugar purchased from all households in the same stratum and division by the number of adult equivalents (AE) existing in the stratum (the weighting factors for each household were employed at this stage). The AE were obtained by dividing the Recommended Dietary Allowance (RDA) for each age–gender group by the average RDA for energy for an adult (10 710 kJ). Individual AE of each household were added to obtain an AE for each stratum[18].

The sociodemographic attributes of each stratum were used to characterize the study units and to control for potential confounder effects on the association between energy from sugar and total energy content of the household food purchase. These attributes included location (North, North-east, South-east, South or Centre–West macro regions) and urban or rural status of the household, in addition to mean per capita household income, proportion of total food expenditure dedicated to meals outside the home, and percentage of members under 20 years, over 64 years and of female gender. In order to arrive at these mean values, we once again employed the weighting factors for each household in the stratum.

Data analysis

The crude relationship between energy from sugar and total energy content of all household food purchases was first described by calculating daily mean adult equivalent energy availability according to quartile of energy purchased from sugar.

The association between energy from sugar and total energy content of all household food purchases, adjusted for confounding variables, was determined by multiple linear regression models using as dependent variable the total energy from all food purchases. In addition to energy from sugar (explanatory variable), we introduced in the models all variables showing P values below 0·20

in bivariate linear regression models for the association with total energy or energy from sugar (potential confounders). We used a backward modelling strategy, removing potential confounders from the 'saturated model' in a stepwise fashion, beginning with the factor with the highest P value. Variables that altered the magnitude of the regression coefficient for the effect of energy from sugar on total energy by at least 5 % were kept in the final model. In addition, we investigated the potential effects of interactions between energy from sugar and confounding variables on total energy, keeping in the final model all significant interactions ($P < 0·05$). In order to provide a visual representation of the effects of interactions on total energy, we plotted graphs representing different scenarios with respect to the variables involved in significant interactions.

The adequacy of the final regression models was tested by residual analysis. In all analyses included in the present study, we employed weighting factors to allow for extrapolation of our results to the Brazilian population. All analyses were performed with the aid of STATA Special Edition statistical software package, version 8·0 (Stata Corporation, College Station, TX, USA).

Results

Table 1 shows a monotonic and significant increase in total energy purchased by Brazilian families as sugar purchases increased, indicating a difference of over 3780 kJ/AE per d among the 25 % that consumed the least and the 25 % that consumed the most sugar. The table also shows that the increase in total energy content is well above that expected if the increase in total energy were due to an increase in sugar purchases alone.

Table 2 shows that all sociodemographic variables investigated were associated with total energy content or with sugar intake at a statistically relevant level ($P < 0·20$). These variables were therefore considered as potential confounders in the association between sugar intake and total energy content.

Table 3 presents the results of the final multiple regression model for total energy purchased by the household including, in addition to energy from sugar, all of the sociodemographic confounders whose removal

Table 1 Total energy content from all food purchases according to amount of sugar purchased, Brazil, 2002–3

Quartile of sugar purchase (kJ/AE per d)	All food purchases (kJ/AE per d)		
	Mean	SE	P
1 (42·4–1097·0)	6693·54	179·34	<0·001*
2 (1097·9–1360·0)	7987·56	138·18	
3 (1362·9–1565·8)	8883·84	161·70	
4 (1566·2–3723·7)	10 711·26	426·72	
Total (42·4–3723·7)	8558·34	158·34	

AE, adult equivalent.
*P for linear trend.

Table 2 Mean energy from all food purchases and mean energy from sugar purchases according to sociodemographic variables, Brazil, 2002–3

Variable	All food purchases (kJ/AE per d)	P	Sugar purchases (kJ/AE per d)	P
Region		0·859		0·007
North	9020·7		1077·3	
North-east	8421·8		1307·9	
South-east	8392·0		1440·6	
South	9274·0		1433·5	
Centre–West	8072·0		1274·7	
Area		<0·001		<0·001
Urban	8056·0		1304·9	
Rural	11 349·7		1735·0	
Per capita family income (R$)*		0·001†		0·129†
67·8–381·3	8691·1		1325·5	
382·2–493·3	9398·3		1541·4	
493·8–725·2	8170·3		1337·7	
730·7–4562·2	7968·7		1276·4	
Total food expenditures on meals outside the home (%)*		<0·001†		<0·001†
1·7–18·4	10 116·1		1518·7	
18·5–20·1	8564·2		1423·4	
20·2–25·7	8087·5		1370·0	
25·8–73·5	7460·0		1168·9	
Under 20 years (%)*		0·993†		0·175†
3·6–30·2	8704·9		1383·5	
30·3–36·4	8411·8		1418·3	
36·5–40·3	8402·9		1413·3	
40·4–61·8	8714·2		1265·9	
Over 64 years (%)*		<0·001†		<0·001†
0·0–6·8	7482·7		1106·3	
6·9–8·6	8516·8		1381·0	
8·7–9·7	9114·0		1537·2	
9·8–20·6	9133·3		1459·9	
Women (%)*		<0·001†		0·006†
39·9–50·3	9775·9		1503·2	
50·4–50·9	8284·1		1336·9	
51·0–52·0	8278·2		1407·8	
52·1–67·0	7871·2		1233·1	
Total	8558·3		1370·5	

AE, adult equivalent.
*Variable intervals correspond to quartiles of the variable distribution.
†P for linear trend.

Table 3 Results of the final multiple linear regression model (without interactions) on the total energy content of all household food purchases (kJ/AE per d), Brazil, 2002–3

Variables in the model	Regression coefficient	95 % CI	R^2
			0·761
Energy from sugar (kJ/AE per d)	3·637	3·122, 4·153	
Household income (log R$/person)	772·846	465·259, 1080·442	
Percentage of total food expenditures on meals outside the home	−50·232	−77·263, −23·201	
Area (0 = urban, 1 = rural)	1656·035	1088·665, 2223·400	
Region			
North			
North-east	−1367·856	−1894·015, −841·697	
South-east	−1936·141	−2462·216, −1410·070	
South	−1272·062	−1889·887, −654·242	
Centre–West	−1642·943	−2195·143, −1090·740	

AE, adult equivalent.

modified by at least 5 % the regression coefficient associated with energy from sugar. This model was able to 'explain' over two-thirds of the variability in total energy purchased by the household ($R^2 = 0·761$). In constructing the model, we tested different transformations for the income variable, with logarithmic transformation yielding the best fit. In the case of sugar, the best fit was obtained without variable transformation.

The estimated regression coefficient for energy from sugar (3·637; 95 % CI 3·122, 4·153) implies that each additional kilojoule from sugar was associated with an increase of over three-and-a-half kilojoules in the total

Table 4 Results of the final multiple linear regression model (with interactions) on the total energy content of all household food purchases (kJ/AE per d), Brazil, 2002–3

Variable in the model	Regression coefficient	95 % CI	R^2
			0·789
Energy from sugar (kJ/AE per d)	−2·611	−6·111, 0 ·889	
Household income (log R$/person)	−1812·523	−2777·305, −847·745	
Percentage of total food expenditures on meals outside the home	−82·551	−207·110, 42·013	
Area (0 = urban 1 = rural)	1206·400	666·023, 1746·570	
Region			
North			
North-east	−1221·692	−1754·785, −688·603	
South-east	−1685·817	−2207·268, −1164·366	
South	−1070·336	−1693·810, −446·863	
Centre–West	−1458·702	−2027·407, −889·997	
Energy from sugar × Household income	6·161	3·714, 8·607	
Energy from sugar × Percentage of total food expenditures on meals outside the home	−0·533	−0·710, −0·353	
Household income × Percentage of total food expenditures with on outside the home	27·959	11·847, 44·071	

AE, adult equivalent.

energy household purchases. In other words, purchasing an additional 1 kJ of sugar leads to the purchase of an 'extra' 2·637 kJ derived from other macronutrients that are not sugar (fats, proteins or other carbohydrates). As expected, a regression coefficient of 2·637 kJ/AE per d was found using a linear regression model identical to that presented in Table 3, but using as a dependent variable total energy purchases excluding energy from sugar (data not shown).

Additional analyses departing from the final multiple regression model showed three significant interactions, between: (i) energy from sugar and family income; (ii) energy from sugar and percentage of total food expenditures on meals outside the home; and (iii) family income and percentage of total food expenditures on meals outside the home. Table 4 shows the results of the final regression model including the effects of these interactions on total energy purchases ($R^2 = 0·789$).

In order for the interaction effects to be more easily visualized, we present three graphs (Figs 1a to 1c) that consider different scenarios in terms of family income and expenditure on meals outside the home. These graphs show the variation in the amount of energy from sugar purchased between a minimum corresponding to the 10th centile of the distribution of sugar purchases in the total household sample of the 2002–3 HBS and a maximum corresponding to the 90th centile of the same distribution. Income is fixed in each of the three graphs at values equivalent, respectively, to the lower, middle and upper quintile of the family income distribution. In each of the three graphs, we present the relationship between energy from sugar and total energy without fixing the percentage of total food expenditures on meals outside the home, as well as under the condition of absence of expenditure on meals outside the home.

In the three income scenarios, increases in sugar purchases are associated with an increase in total energy purchases, which are, as expected, always higher for no

expenditure on meals outside the home. Particularly relevant are the predictions regarding total energy with no expenditure on meals outside the home since, under this condition, the household food purchase would tend to be closer to the actual energy intake of household members. Under the condition of zero expenditure on meals outside the home, purchasing an amount of sugar corresponding to the 90th centile of the distribution of sugar purchasing in the country (1926·35 kJ/AE per d) would be associated with a total energy purchase of 13 136 kJ/AE per d in low-income households (lower quintile), 14 074 kJ/AE per d in intermediate-income households (middle quintile) and 15 172 kJ/AE per d in high-income households (upper quintile).

We also tested independent models for urban and rural households. Differences between these models and that contemplating the entire sample were only slight, and therefore these data are not presented.

Discussion

Based on a probabilistic survey representative of the totality of Brazilian households, the present study has shown evidence of a positive and significant association between energy from sugar and the total energy content of all household food purchases: a 1 kJ increase in sugar purchases corresponded to a 3·637 kJ increase in total energy. In other words, purchasing an additional 1 kJ of sugar leads to the purchase of an 'extra' 2·637 kJ derived from other macronutrients that are not sugar (fats, proteins or other carbohydrates). Under the condition of an absence of expenditure on meals outside the home, and therefore given a scenario in which household food purchases would tend to approximate the actual food consumption of household members, a sugar purchase of 1926·35 kJ/AE per d (the 90th centile of the distribution of sugar purchasing in Brazil) would be associated, across all income
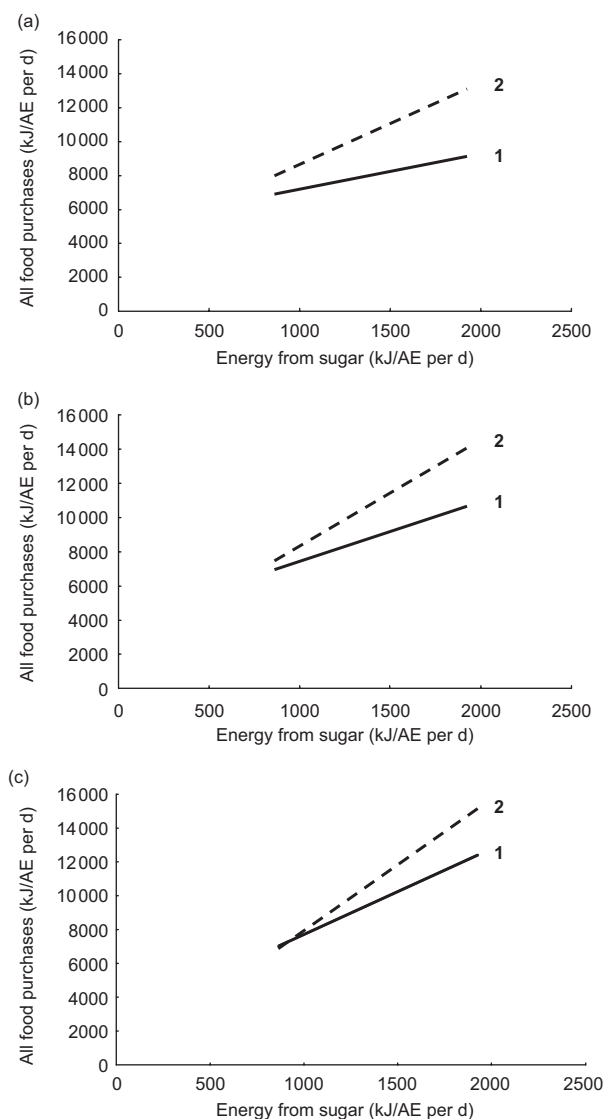
Fig. 1 Estimates based on the multiple linear regression model (with interactions) for the association between energy from sugar and total energy content of all food purchases, according to quintiles of the per capita household income distribution, contemplating two scenarios in terms of the percentage of total food expenditures on meals outside the home, Brazil, 2002–3: (a) lower income quintile; (b) middle income quintile; (c) upper income quintile. Scenario 1 (——): prediction done with per capita household income fixed at the mean income level of the lower, middle or upper quintile of the distribution of per capita household income, with the remaining explanatory variables in the model, except for energy from sugar, fixed at the mean value. Scenario 2 (– – –): prediction as for Scenario 1, but with the percentage of total food expenditures on meals outside the home fixed at zero. AE, adult equivalent

strata, with a total energy content of food purchases far above the recommended 7998·00 kJ/d intake in Brazil[19].

Major limitations of the present study are related to the limitations of household budget surveys to accurately describe household food intake; that is, failure to consider both food eaten outside the home and the proportion of food purchased but not consumed by household members.

These limitations are compounded, in the case of the 2002–3 HBS, by the short duration (one week) of the reference period for collection of data on the food purchases made by each household.

In the present study, we attempted to control for the potential effect of food eaten outside the home by introducing, into the regression models, the percentage of total food expenditures on meals outside the home. We consider that, when also controlling for income, this percentage can be assumed to be a reasonable proxy for energy consumption outside the household.

Regarding food purchased but not consumed, it is initially reasonable to assume that this would occur to any relevant extent only among higher-income strata. Notwithstanding, in order for the relationship evidenced by the present study between sugar intake and total energy intake to be affected by the eventual wastage of food, it would be necessary for the non-consumed proportion of sugar to differ substantially from the non-consumed proportion of other foods.

To address the problem of the short reference period for data collection in each household, we adopted as units of analysis groups of households homogeneous as to geographic location and socio-economic characteristics, and which were studied in a uniform manner throughout the four trimesters of the year.

In favour of the relative accuracy of the HBS in assessing the contribution of sugar to the diet of the Brazilian population is the similarity between the proportion of energy from sugar found in the present survey (16·0 %) and that estimated based on the country's food balance sheets for 2002–3 (17·7 %)[3].

Notwithstanding the limitations typical of household budget surveys, studies comparing their results with those of individual intake surveys have found considerable agreement between the two methods[20,21]. For example, a study carried out in four European countries showed a correlation coefficient of 0·74 between sugar intake as measured by a household budget survey and by an individual food consumption survey[20]. Certain authors even defend the hypothesis that, in the case of foods used as cooking ingredients such as sugar, household budget surveys may more accurately reflect actual intake than individual food intake surveys. This would be due to the difficulty of individuals in reporting the amount of intake of a food ingested as part of a recipe[21].

Another limitation refers to the impossibility to examine separately the effect of sugar from beverages. There is growing evidence that sugared beverages in particular increase the risk of over-consumption of energy and thus of overweight and obesity[10,12,22]. In any case, as our data refer to food acquisition information, it is impossible to know in which form the sugar acquired by the household is going to be consumed.

Two strengths of the present study are the nationwide representativeness of the studied sample and statistical

control for several sociodemographic characteristics that may act as confounders or effect modifiers in the association between energy from sugar and total energy content of food purchases. Regarding the latter, however, as in any other observational study, one cannot discard the possibility of influence by confounders not considered in the present analysis.

A population-based study carried out in the USA analysed the effect of sugar intake on total energy content of the diet of children aged 2 to 5 years. Analyses were stratified according to age, 2–3 years or 4–5 years, and children were classified into five groups according to the percentage contribution of sugar to the diet. The study reported a significant increase in total energy content in the diet of younger – but not older – children along with increases in the percentage contribution of sugar[14]. Another American study investigated the effect of total sugar in the diet (in this case, considering intrinsic sugars as well) on total energy content in the diet of children aged 10 years, but did not find any significant associations[23]. A population-based study in South Africa also showed that total energy intake was not significantly greater in the highest tertile of sugar intake, for which the average consumption was 57·9 g sugar/d (18·2 % of total energy intake)[24].

It is worth mentioning that studying the association between contribution of sugar (or any other food) in the diet and the diet total energy content – as was the case in the two American and the South African studies mentioned above – can be criticized for including total energy on both sides of the association equation[25].

A 12-month prospective study carried out in the USA detected a significant association between soft drink consumption and weight gain among adolescents aged 9 to 14 years. These authors argue that a likely mechanism for this association is the increase in total energy content of the diet determined by soft drink intake, since the effect of soft drinks on overweight was strongly attenuated by controlling for total energy content in the diet[26]. A positive association between soft drink intake and weight gain or obesity, or even metabolic syndrome, especially among children and adolescents, has been shown by studies carried out in the USA and Canada[22–30].

Brazilian studies directly evaluating the effect of sugar intake on total energy content, or even on overweight or obesity, will be required to confirm the results of the present study based on household food purchases. In any case, our results corroborate both international[1] and national[19] recommendations for population-wide reduction in the consumption of sugar.

Acknowledgements

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