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# Associations between children's reports of food insecurity and dietary patterns: findings from the Generation XXI birth cohort

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## Abstract

Evidence on the association between children's food insecurity (FI) and dietary patterns (DPs) is scarce. This study assessed the association between children's FI and *a priori* and *a posteriori*-defined DPs in a Portuguese population-based sample of children. A cross-sectional study including 2800 children from the 10-year-old follow-up of the Generation XXI birth cohort was performed. Data on food security status, assessed by the Self-administered Food Security Survey Module for children (SAFSSMC), dietary intake and socio-demographics were collected. A previously developed Healthy Eating Index (HEI) was adapted for this study. Using the HEI score and its food groups, linear and logistic regression models were performed. Using latent class analysis, five *a posteriori*-defined DPs were identified. The DPs names considered an overall picture of the DP. Food security status as a categorical (food security/FI) and continuous variable (SAFSSMC raw score: higher scores representing higher FI) was used. Multinomial logistic regression models were used to assess the association between food security status and DPs. Children's FI (9·4 %) was inversely associated with the HEI score ($\beta$=–0·695;95%CI:–1·154,–0·235), representing worse diet quality. A higher SAFSSMC raw score was associated with low fruit and vegetables (OR=1·089;95%CI:1·023,1·159) and seafood and eggs consumption (OR=1·073;95% CI:1·009,1·142) and high consumption of meat and meat products (OR=1·091;95%CI:1·026,1·160), salty snacks (OR=1·067;95% CI:1·003,1·136) and soft drinks (OR=1·097;95%CI:1·031,1·168). The SAFSSMC raw score was positively associated with 'Low consumption' (OR=1·119;95%CI:1·016,1·232), 'Energy-dense foods' (OR=1·155;95%CI:1·028,1·298) and 'Snacking' (OR=1·119;95%CI:1·006,1·245) DPs. FI was associated with worse dietary choices. Intervention strategies targeting food insecure children should be developed to promote healthy dietary habits.

**Keywords: Children: Food insecurity: Dietary intake: Feeding behaviours: Healthy Eating Index: *a posteriori*-defined dietary patterns**

Food insecurity (FI), defined as '*limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways*'[1], is of great public health relevance. According to a previous national survey – the National Food, Nutrition, and Physical Activity Survey of the Portuguese General Population (2015–2016) – 10·1 % of the Portuguese families experienced FI, this prevalence increased to 11·4 % when there were individuals younger than 18 years old in the household[2], emphasising households with children as more likely to be food insecure[2,3].

FI can induce long-term health and behavioural effects, particularly in children. Previous studies have highlighted some adverse effects that FI may have on children. Beyond the impact on health[4], inadequacy in dietary behaviour has also been described[5–8]. However, despite some evidence reporting the association of FI with poor dietary quality and unhealthier dietary behaviours, the literature is not consensual[7–9]. Evidence from a systematic review showed that FI was less consistently associated with lower dietary quality in children when compared with adults[10]. One of the reasons that can contribute to this finding is that FI assessment at the household level and/or based on parents reports may not be indicative of children's FI[11], as parents and children might have different FI perceptions[12]. Furthermore, children, particularly young children, tend to be protected from the effects of FI[11], which can also justify this finding.

**Abbreviations:** DP, dietary pattern; FI, food insecurity; SAFSSMC, Self-administered Food Security Survey Module for Children.

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As aforementioned, most frequently the relationship between FI and dietary intake based on parents/caregivers reports and/or at the household level was explored[9]. Less often, individual children's reports of FI are used[6]. Indeed, previous studies reported a disagreement between parents and children perceptions of FI[12–16].

Also, most diet and nutrition analyses focused on foods, food groups or selected nutrients[8,17] and less frequently defined diet as a whole, through dietary patterns (DPs)[6]. *A priori* and *a posteriori*-defined DPs allow to describe food intake complexity, by examining the effects of overall diet rather than looking at individual nutrients or foods. DPs are also easier to understand by the general population[18].

To the best of our knowledge, data on the association between children's self-reports of FI and *a priori* or *a posteriori*-defined DP are scarce, particularly in European countries, corroborating the relevance of further studies. Therefore, this study aimed to evaluate the association between children's self-reports of FI and *a priori* and *a posteriori*-defined DPs in a Portuguese population-based cohort of children.

## Methods

### Study design and participants

A cross-sectional study was performed using data from the population-based birth cohort Generation XXI, described elsewhere[19,20]. Briefly, between 2005 and 2006, 8647 live newborns and their mothers were recruited from the five public maternity units of Porto Metropolitan Area, Portugal. Follow-up evaluations occurred at 4, 7 and 10 years old. From 2015 to 2017, the 10-year-old follow-up was performed, and 6397 children were evaluated. Within this follow-up, a sub-sample of 2987 children was consecutively invited for food security status assessment. Singletons or one of the children (first twin/sibling), in the case of multiple births or siblings, were considered for this study ($n$ 2912). Children with conditions likely to influence dietary intake (e.g. coeliac disease, food allergy and congenital malformation) ($n$ 10), and individuals with missing information on food security status, dietary intake, socio-demographic or behavioural characteristics ($n$ 102) were excluded, corresponding to a final sample of 2800 children (Fig. 1).

At the 10-year-old follow-up, children included in this study, when compared with those not included, were mostly boys (52·7 % *v.* 50·0 %; $P = 0·034$; Cramer's V = 0·027), had more often high educated mothers (> 12 years) (32·3 % *v.* 24·2 %; $P < 0·001$; Cramer's V = 0·114) and were less likely to belong to a low-income family (≤ 1000 €) (24·3 % *v.* 32·4 %; $P < 0·001$; Cramer's V = 0·098).

Generation XXI was conducted according to the Ethical Principles for Medical Research Involving Human Subjects laid down in the Declaration of Helsinki, and all procedures were approved by the Ethics Committee of University of Porto Medical School/Centro Hospitalar Universitário São João. The Portuguese Data Protection Authority also approved Generation XXI. All the parents or legal representatives provided written informed consent, in the baseline and the subsequent follow-up evaluations.

### Data collection

Data were collected using structured questionnaires. Information from the baseline evaluation on child's sex, maternal education, as well as from the 10-year-old follow-up on the food security status, dietary intake, and child's age, caregivers' unemployment and household size, anthropometrics and regular practice of physical exercise were collected.

*Food security status.* Food security status was assessed using the Self-administered Food Security Survey Module for children (SAFSSMC)[21]. It was applied separately from the parent/accompanying adult and is composed of nine items with three answer options ('a lot', 'sometimes' and 'never') (online Supplementary Table S1), which asked about the food situation in the child's household related to the previous month[21]. This questionnaire took about 5 min to be answer by the children. 'A lot' and 'sometimes' were considered as affirmative responses, and 'never' was considered a negative response. The raw score represents the sum of affirmative responses of the items of the scale[21]. According to the proposed and validated classification for Portuguese children (Cronbach's $\alpha = 0·617$)[22], they were considered as 1) food insecure if the raw score was equal to or higher than four or if the raw score was equal to two or three but including a negative response in the item related to worrying that food at home would run out (item 1), or if the raw score was equal to three and including an affirmative response to the item 1 and a negative response in the item related to meals only including a few kinds of cheap foods (item 3) and 2) food secure if the raw score was lower than or equal to one, or if the raw score ranged between two and three but including affirmative responses for items 1 and 3, or if the raw score was equal to two and including an affirmative response in item 1, but a negative response in item 3.

*Dietary intake.* Children's dietary intake was collected through a validated FFQ[23] and 3-d food diaries (two weekdays and one weekend day). The FFQ was composed of forty-one food items covering the previous 6 months before the interview and applied to the children's caregiver by trained interviewers, and the duration of questionnaire was around 10 min. The mean daily consumption (in grams per day) was estimated using a z-score method based on the frequency reported in the FFQ and the mean and standard deviation of food consumption reported in 3-d food diaries, as previously described[23]. Foods were converted into nutrients using the Food Processor SQL (2004–2005 ESHA Research) software, based on the Food Composition Table of the United States Department of Agriculture[24], and, in the case of typical Portuguese foods or dishes, new codes were generated with national nutritional composition data.

*A priori-defined dietary pattern – the Healthy Eating Index.* A Healthy Eating Index (HEI) – an *a priori*-defined DP – was created based on the dietary recommendations proposed by the WHO[25] for children from the Generation XXI cohort at 4 years[26]. For the current study, this HEI was adapted and intends to evaluate the dietary quality at 10 years. Similar to the

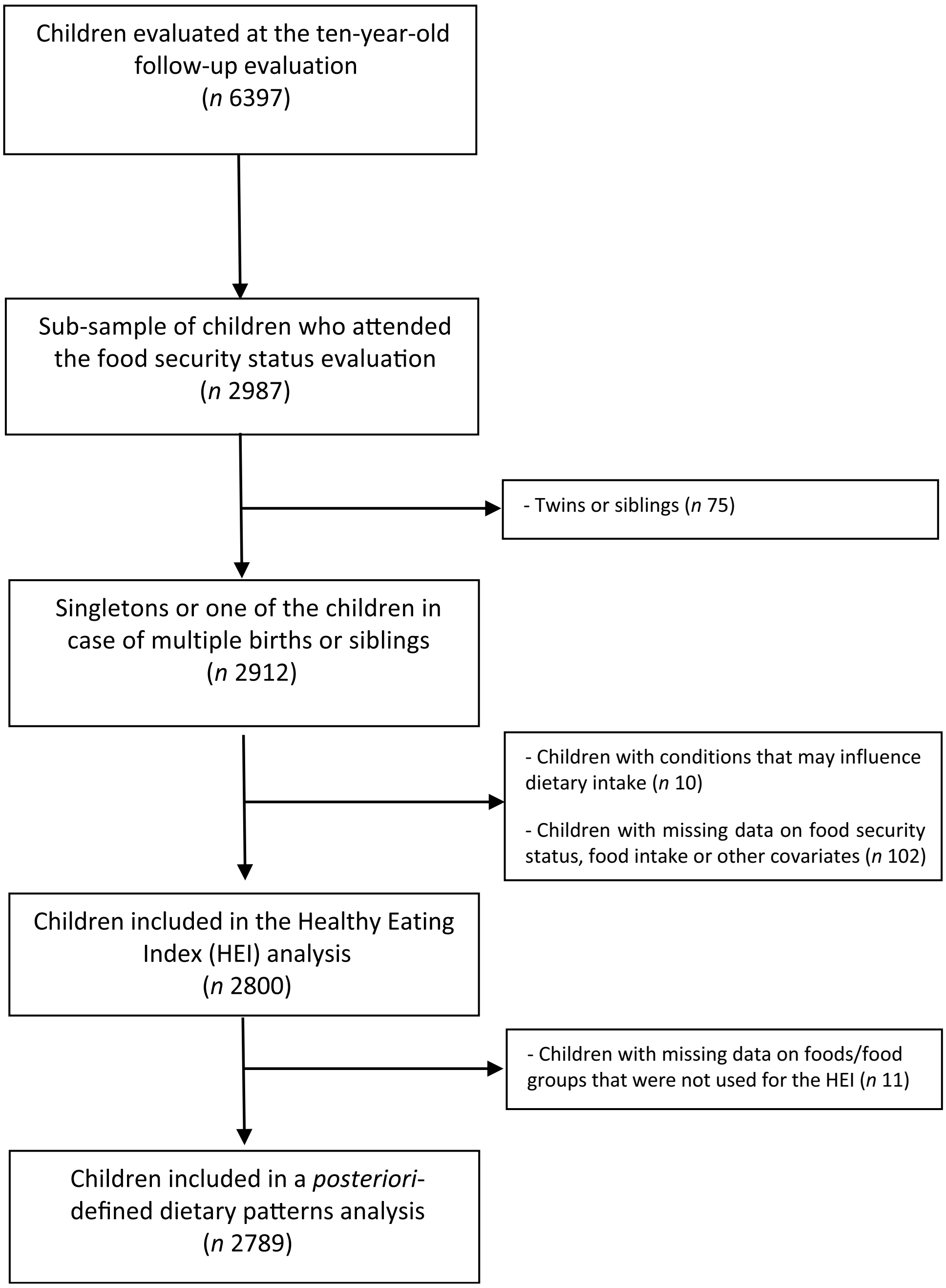


**Fig. 1.** Flow diagram of the included children from the Generation XXI birth cohort.

previously developed index[26], the used HEI comprises seven food groups: fruit and vegetables (vegetable soup, vegetables and fruit and excluding fruit juices); dairy products (semi-skimmed milk, skimmed milk, cheese and yoghurts); meat and meat products (meat and processed meat like sausages and ham); seafood and eggs; sweet snacks (ice cream, cakes, cookies, sweet pastries, chocolates and candies); salty snacks (salty pastry, crisps, chips, pizzas and burgers) and soft drinks (sugar-sweetened beverages and other sweet drinks, including diet drinks). Quartiles of daily food group consumption were calculated for each food group, and an increasing score varying between one and four was attributed to each quartile. For healthier food groups (fruit and vegetables, dairy products and seafood and eggs), the lowest quartile of consumption was given a score of one, intermediate quartiles were assigned with a score of two and three and the highest quartile was given a score of four. For the remaining food groups, which are not recommended on a daily basis in the context of a healthy diet (sweet snacks, salty snacks and soft drinks), a reverse score was assigned (the highest score to the lowest quartile of food consumption). In a perspective of both health and environmental sustainability[27], meat and meat products were also reversely scored. In the HEI previously adapted for Generation XXI cohort[26], white meat, seafood and eggs were included in the same food group. For this study, we needed to exclude white meat because the FFQ used in the 10-year-old evaluation has one single item for assessing meat consumption, thus both lean meat and red meat are within the same item.

Each food group scores was summed up and the final score could range from seven to twenty eight.

*A posteriori-defined dietary patterns.* Following the same methodology that was used in previous studies in this cohort at 4 and 7 years[28,29], DPs were identified using Latent Class Analysis. This methodology describes how the probabilities of the food categories of the FFQ vary across different groups of individuals. This allows to differentiate classes of similar individuals within groups and find the smallest number of latent classes (in this case, DPs)[30]. The interpretation of the latent classes is made by observing the probability of selecting each food item category within each class, called item profile.

For this analysis, nineteen food items and/or food groups were used: milk, yoghurt, cheese, eggs, meat, processed meat, seafood, bread, vegetable soup, vegetables on a plate, fruit, crisps, pizza/burger, salty pastry, butter, cookies, candies, coffee/tea and soft drinks. Each food item or group was classified into quintiles of food consumption (in grams per day), which were further categorised into three groups: first quintile, second to the fourth quintile and fifth quintile (online Supplementary Table S2). As the fourth quintile was equal to the fifth quintile for seafood and soup, only two categories were considered.

The number of DPs was defined according to the lowest Bayesian Information Criteria (four DPs: Bayesian Information Criteria = 167 346·9; five DPs: Bayesian Information Criteria = 167 314·9, six DPs: Bayesian Information Criteria = 167 360·2). Thus, five DP were obtained as the best solution.

Children were allocated to each class (DP) according to the highest probability of class membership (online Supplementary Table S3). Class 1 presented a higher proportion of children in the highest consumption category of vegetables, vegetable soup, fruit and seafood, and a higher proportion of children in the first quintile (lowest consumption) of milk, processed meat, crisps, pizza/burger, salty pastry, cookies, candies and soft drinks, thus, was labelled as 'Healthier' DP. In class 2, a higher proportion of children within the first quintile of consumption (i.e. lower consumption) of several food groups: yoghurts, cheese, eggs, seafood, bread, vegetables, fruit, butter and coffee/tea was observed, without any other relevant differences, and named as 'Low consumption' DP. In class 3, there was a higher proportion of children in the fifth quintile of consumption of crisps, pizza/burger, salty pastry, cookies, candies and soft drinks, and at the same time a higher proportion of children with lower consumption of vegetable soup and seafood, being this DP named as 'Energy-dense foods'. In class 4, a higher proportion of children in the fifth quintile of consumption of milk, yoghurt, cheese, processed meat, bread, butter and coffee/tea was observed. As these foods or food groups are usually consumed between main meals, this DP was named 'Snacking'. Finally, in class 5, an intermediate consumption of several food groups was observed, particularly of milk, yoghurts, cheese, eggs, processed meat, fruit, butter, cookies, candies and soft drinks, being named as 'Intermediate consumption' DP.

The names given to each dietary pattern resulted from an arbitrary decision of the researchers and considered an overall picture of the DP, as commonly done.

*Covariates.* The regular practice of physical exercise outside school was asked and classified as a dichotomous variable (yes and no) and as a continuous variable, reflecting the time per week spent on its practice.

Anthropometric measurements (weight and height) were performed according to standard procedures[31], with children in light clothing and barefooted. Weight was measured by using a digital scale (TANITA® UM-018) to the nearest 0·1 kg, and height was measured using a stadiometer (SECA® 206) to the nearest 0·1cm. Age and sex-specific BMI reference z-scores were calculated according to the WHO[32].

Maternal education, as the number of completed years of formal schooling, was classified according to the International Standard Classification of Education 2011 classes[33] as low (≤ nine years), intermediate (10 to 12 years) and high (> 12 years). Caregivers' unemployment was accounted for as if one or both caregivers were unemployed and classified as yes and no. The household size represents the number of persons within the household.

## Statistical analysis

Continuous variables were summarised as median, percentile 25 (P25) and percentile 75 (P75) and compared using the Mann–Whitney *U* test. Categorical variables were described as counts and proportions and compared using the $\chi^2$ test.

To assess the association between food security status and *a priori*-defined DPs, a continuous *a priori*-defined DP was used – HEI –, and linear regression models were performed.

Also, a sensitivity analysis was conducted for HEI food groups. Each food group was categorised into two categories according to the sample median consumption (< median and ≥ median), and logistic regression models were computed. Crude and adjusted models were calculated, and the models for the HEI final score, as well as for individual food groups, were adjusted for maternal education, caregivers' unemployment and child's sex. Linear regression coefficients ($\beta$) and OR were computed, in linear and logistic regressions, respectively, and the respective 95 % CIs.

For the *a posteriori*-defined DPs analysis, eleven children were further excluded as they had missing data on foods/food groups that were not used for the HEI (Fig. 1). To evaluate the association between food security status and *a posteriori*-defined DPs, multinomial logistic regression models were computed ('Healthier' DP as reference category), and OR and 95 % CIs were calculated. Crude and adjusted models were performed. Adjustments for maternal education, caregivers' unemployment and child's sex were done.

In both analyses, food security status, as categorical – food security and FI – and as continuous variables – SAFSSMC raw score (higher scores representing higher FI) – were used.

In another sensitivity analysis, other confounders were tested. Although the practice of physical exercise and the z-score of BMI did not theoretically fulfil the criteria of confounders, they were tested as covariates, but no considerable differences in the coefficients were observed, and so they were not included. Moreover, interactions of child' sex, maternal education and caregivers' unemployment were explored, but no significant interactions were observed.

Statistical analysis was performed using SPSS Statistics 27·0 (IBM Corp.) and also using Mplus version 6 for the latent class analysis. A significance level of 0·05 was used.

## Results

The characteristics of the sample are presented in Table 1. Children had a median age of 11·0 years (P25–P75: 11·0; 11·0) and were mostly boys (52·7 %). A FI prevalence of 9·4 % was observed. The median energy intake was 1944·0 kcal/d (1710·4; 2278·1).

Food-insecure children were less likely to practice physical exercise (55·7 % *v.* 69·1 %) and presented a higher WHO z-score BMI (0·9 (–0·04;1·8) *v.* 0·6 (–0·2;1·6)) compared with food secure children. Also, food-insecure children presented a higher median energy intake than food secure ones (2024·7 kcal/d (1723·4; 2437·9) *v.* 1938·4 kcal/d (1708·8; 2259·1)).

### A priori-*defined dietary pattern*

The median of the HEI score was 18·0 (15·0; 21·0), ranging between seven and twenty eight (Table 1). Children in the third HEI tertile (higher score), compared with the other two categories, presented lower median daily energy intake, as well as lower median daily intake of carbohydrates, total fat, saturated fat, monounsaturated and polyunsaturated fat and a higher daily intake of fibre, calcium and vitamins C and D, supporting a higher quality of the diet (online Supplementary Table S4).

Food-insecure children had a significantly lower HEI score (low diet quality), when compared with food secure (17·0 (14·0; 20·0) *v.* 18·0 (15·0; 21·0); $P < 0·001$). Moreover, food-insecure children showed to have significantly lower daily consumption of fruit and vegetables (320·8g (257·2; 385·7) *v.* 344·7g (274·5; 410·4); $P = 0·001$), seafood and eggs (71·1g (54·4; 76·9) *v.* 72·4g (54·4; 90·4); $P < 0·001$) and a higher daily consumption of meat and meat products (145·7g (130·3; 169·2) *v.* 143·6g (124·8; 156·6); $P < 0·001$), salty snacks (10·7g (0·0; 33·0) *v.* 4·5g (0·0; 22·3); $P = 0·003$) and soft drinks (159·8g (20·1; 271·0) *v.* 95·5g (0·0; 237·3); $P = 0·002$) (Table 2).

In Table 3, the associations between food security status and diet quality are summarised. FI was negatively associated with the HEI ($\beta = –1·125$; 95 % CI: –1·598, –0·653). After adjustment for maternal education, caregivers' unemployment and child's sex ($\beta = –0·695$; 95 % CI: –1·154, –0·235), the association remained statistically significant. Similar results were observed with the SAFSSMC raw score ($\beta = –0·190$; 95 % CI: –0·296, –0·085).

Food-insecure children showed to have higher odds of having lower fruit and vegetables (OR = 1·431; 95 % CI: 1·106, 1·851) and seafood and eggs (OR = 1·584; 95 % CI: 1·224, 2·050) consumption and high consumption of meat and meat products (OR = 1·664; 95 % CI: 1·277, 2·168).

When adjusted for maternal education, caregivers' unemployment and child's sex, only the positive associations between FI and lower consumption of seafood and eggs (OR = 1·347; 95 % CI: 1·033, 1·756) and high consumption of meat and meat products (OR = 1·477; 95 % CI: 1·128, 1·934) remained statistically significant. On the other hand, using the SAFSSMC raw score, the association with fruit and vegetables remained significant, independently of maternal education, caregivers unemployment and child's sex (OR = 1·089; 95 % CI: 1·023, 1·159). Furthermore, similar to what was observed using the food security status classification, that children classified as being food

**Table 1.** Characteristics of 10-year-old children of the Generation XXI birth cohort, included in this study (*n* 2800)

| | *n* | % |
|---|---|---|
| Child's sex* | | |
| Girls | 1325 | 47·3 |
| Boys | 1475 | 52·7 |
| Maternal education* | | |
| Low | 1075 | 38·4 |
| Intermediate | 820 | 29·3 |
| High | 905 | 32·3 |
| Caregivers' unemployment* | | |
| No | 2222 | 79·4 |
| Yes | 578 | 20·6 |
| Household size† | | |
| Median | 4·0 | |
| P25;P75 | 3·0;4·0 | |
| WHO z-score BMI† | | |
| Median | 0·6 | |
| P25;P75 | –0·2;1·6 | |
| Practice of physical exercise* | | |
| No | 899 | 32·1 |
| Yes | 1901 | 67·9 |
| Hours/week† | | |
| Median | 2·0 | |
| P25;P75 | 0·0;4·0 | |
| Food security status* | | |
| Food security | 2538 | 90·6 |
| Food insecurity | 262 | 9·4 |
| SAFSSMC raw score† | 1·0 | 0·0;2·0 |
| | Median | P25;P75 |
| Energy intake (kcal/d)† | 1944·0 | 1710·4;2278·1 |
| *A priori*-defined DP | | |
| HEI† | 18·0 | 15·0;21·0 |
| HEI food groups (g/d)† | | |
| Fruit and vegetables | 342·6 | 273·6;410·0 |
| Meat and meat products | 143·6 | 124·8;156·6 |
| Seafood and eggs | 71·1 | 54·4;90·4 |
| Dairy foods | 531·5 | 470·0;619·2 |
| Sweets snacks | 69·3 | 28·8;106·1 |
| Salty snacks | 4·5 | 0·0;23·2 |
| Soft drinks | 95·5 | 0·0;239·3 |
| | *n* | % |
| *A posteriori*-defined DPs (*n* 2789)* | | |
| Healthier | 614 | 22·0 |
| Low consumption | 643 | 23·0 |
| Energy-dense foods | 262 | 9·4 |
| Snacking | 399 | 14·3 |
| Intermediate consumption | 871 | 31·2 |

DP, dietary pattern; HEI, Healthy Eating Index; SAFSSMC, Self-administered Food Security Survey Module for Children.
* *n* (%).
† Median (P25;P75).

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**Table 2.** Characteristics of children according to the food security status

| | Food security (*n* 2538 (90·6 %)) | | Food insecurity (*n* 262 (9·4 %)) | | |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | *P* value |
| Child's sex* | | | | | < 0·001 |
| Girls | 1238 | 48·8 | 87 | 33·2 | |
| Boys | 1300 | 51·2 | 175 | 66·8 | |
| Maternal education* | | | | | < 0·001 |
| Low | 930 | 36·6 | 145 | 55·3 | |
| Intermediate | 754 | 29·7 | 66 | 25·2 | |
| High | 854 | 33·6 | 51 | 19·5 | |
| Caregivers' unemployment* | | | | | < 0·001 |
| No | 2043 | 80·5 | 179 | 68·3 | |
| Yes | 495 | 19·5 | 83 | 31·7 | |
| Household size† | | | | | |
| Median | 4·0 | | 4·0 | | 0·011 |
| P25;P75 | 3·0;4·0 | | 3·0;5·0 | | |
| WHO z-score BMI† | | | | | |
| Median | 0·6 | | 0·9 | | 0·018 |
| P25;P75 | −0·2;1·6 | | −0·04;1·8 | | |
| Practice of physical exercise* | | | | | < 0·001 |
| No | 783 | 30·8 | 116 | 44·3 | |
| Yes | 1755 | 69·1 | 146 | 55·7 | |
| | Median | P25;P75 | Median | P25;P75 | |
| Hours/week† | 2·0 | 0·0;4·0 | 1·0 | 0·0;3·0 | < 0·001 |
| Energy intake (kcal/d)† | 1938·4 | 1708·8;2259·1 | 2024·7 | 1723·4;2437·9 | 0·011 |
| *A priori*-defined DP | | | | | |
| HEI† | 18·0 | 15·0;21·0 | 17·0 | 14·0;20·0 | < 0·001 |
| HEI food groups (g/d)† | | | | | |
| Fruit and vegetables | 344·7 | 274·5;410·4 | 320·8 | 257·2;385·7 | 0·001 |
| Meat and meat products | 143·6 | 124·8;156·6 | 145·7 | 130·3;169·2 | < 0·001 |
| Seafood and eggs | 72·4 | 54·4;90·4 | 71·1 | 54·4;76·9 | < 0·001 |
| Dairy foods | 530·5 | 470·0;619·2 | 552·4 | 478·0;624·1 | 0·065 |
| Sweets snacks | 69·3 | 28·8;105·9 | 67·4 | 32·2;115·7 | 0·525 |
| Salty snacks | 4·5 | 0·0;22·3 | 10·7 | 0·0;33·0 | 0·003 |
| Soft drinks | 95·5 | 0·0;237·3 | 159·8 | 20·1;271·0 | 0·002 |
| | *n* | % | *n* | % | |
| *A posteriori*-defined DPs* | | | | | 0·010 |
| Healthier | 574 | 22·7 | 40 | 15·3 | |
| Low consumption | 572 | 22·6 | 71 | 27·1 | |
| Energy-dense foods | 229 | 9·1 | 33 | 12·6 | |
| Snacking | 355 | 14·0 | 44 | 16·8 | |
| Intermediate consumption | 797 | 31·5 | 74 | 28·2 | |

DP, dietary pattern; HEI, Healthy Eating Index; P25; percentile 25; P75, percentile 75.
* *n* (%).
† Median (P25;P75).

insecure were more prone to have a higher consumption of meat and meat products, a similar trend was observed using the raw score of the SAFSSMC (OR = 1·091; 95 % CI: 1·026, 1·160). Although the associations between FI and salty snacks and soft drinks consumption equal to or above the median were only significant in the crude models, when the SAFSSMC raw score was used, the associations remained significant, independently of the confounders (OR = 1·067; 95 % CI: 1·003, 1·136 and OR = 1·097; 95 % CI: 1·031, 1·168 for salty snacks and soft drinks, respectively).

## A posteriori-*defined dietary patterns*

The most frequent DP was the 'Intermediate consumption' DP (31·2 %). A total of 22·0 % and 23·0 % of children were classified as following the 'Healthier' and the 'Low consumption' DPs, respectively. A smaller percentage followed the 'Snaking' (14·3 %) and the 'Energy-dense foods' (9·4 %) DPs (Table 1). Children in the 'Healthier' DP showed a lower median energy intake, as well as a lower median daily intake of carbohydrates, saturated fat, monounsaturated and polyunsaturated fat, and a higher daily intake of vitamin C, while children in the 'Energy-dense foods' DP presented the highest energy intake, carbohydrates, total fat, saturated fat, monounsaturated, polyunsaturated and trans-fatty acids intake (online Supplementary Table S4).

Food insecure children were less likely to follow the 'Healthier' DP, but more prone to belong to the 'Low consumption', 'Energy-dense foods' or 'Snacking' DPs ($P = 0{\cdot}010$) (Table 2).

Although in the crude models, FI showed to be positively associated with the 'Low consumption', 'Energy-dense foods' and 'Snacking' DPs, comparing with the 'Healthier' DP, in multivariate analyses, no significant results were obtained. However, using the SAFSSMC raw score, for each unit increase, the odds of belonging to the 'Energy-dense foods', 'Low consumption' and 'Snacking' DPs increase around 16 % (OR = 1·155; 95 % CI: 1·028, 1·298), 12 % (OR = 1·119; 95 % CI: 1·016, 1·232) and

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**Table 3.** Associations between children's food security status and *a priori* and *a posteriori*-defined dietary patterns
(Coefficients values and 95 % confidence intervals)

| | | Food Insecurity | | | | SAFSSMC raw score | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Outcomes* | | Crude model | | Adjusted model* | | Crude model | | Adjusted model* | |
| *A priori*-defined DP | Food Security | $\beta$ (95 % CI) | | | | | | | |
| HEI total score | Ref. | –1·125 | –1·598, –0·653 | –0·695 | –1·154, –0·235 | –0·354 | –0·461, –0·247 | –0·190 | –0·296, –0·085 |
| HEI food groups | | OR (95 % CI) | | | | | | | |
| Fruit and vegetables | | | | | | | | | |
| < 342·6 g/d (median) | Ref. | 1·431 | 1·106, 1·851 | 1·187 | 0·908, 1·553 | 1·172 | 1·104, 1·244 | 1·089 | 1·023, 1·159 |
| Meat and meat products | | | | | | | | | |
| ≥ 143·6 g/d (median) | Ref. | 1·664 | 1·277, 2·168 | 1·477 | 1·128, 1·934 | 1·135 | 1·069, 1·204 | 1·091 | 1·026, 1·160 |
| Seafood and eggs | | | | | | | | | |
| < 71·1 g/d (median) | Ref. | 1·584 | 1·224, 2·050 | 1·347 | 1·033, 1·756 | 1·138 | 1·072, 1·208 | 1·073 | 1·009, 1·142 |
| Dairy foods | | | | | | | | | |
| < 531·5 g/d (median) | Ref. | 0·778 | 0·603, 1·005 | 0·877 | 0·675, 1·138 | 0·932 | 0·879, 0·988 | 0·962 | 0·906, 1·022 |
| Sweet snacks | | | | | | | | | |
| ≥ 69·3 g/d (median) | Ref. | 0·914 | 0·709, 1·179 | 0·891 | 0·689, 1·154 | 0·991 | 0·936, 1·050 | 0·983 | 0·926, 1·043 |
| Salty snacks | | | | | | | | | |
| ≥ 4·5 g/d (median) | Ref. | 1·405 | 1·073, 1·840 | 1·308 | 0·995, 1·719 | 1·092 | 1·028, 1·160 | 1·067 | 1·003, 1·136 |
| Soft drinks | | | | | | | | | |
| ≥ 95·5 g/d (median) | Ref. | 1·539 | 1·187, 1·995 | 1·287 | 0·983, 1·683 | 1·175 | 1·107, 1·248 | 1·097 | 1·031, 1·168 |
| ***A posteriori*-defined DPs** | | | | | | | | | |
| Healthier | Ref. | Ref. | | Ref. | | Ref. | | Ref. | |
| Low consumption | Ref. | 1·718 | 1·189, 2·669 | 1·334 | 0·877, 2·028 | 1·249 | 1·139, 1·371 | 1·119 | 1·016, 1·232 |
| Energy-dense foods | Ref. | 2·068 | 1·272, 3·361 | 1·465 | 0·888, 2·419 | 1·312 | 1·173, 1·468 | 1·155 | 1·028, 1·298 |
| Snacking | Ref. | 1·779 | 1·136, 2·784 | 1·427 | 0·902, 2·256 | 1·214 | 1·094, 1·347 | 1·119 | 1·006, 1·245 |
| Intermediate consumption | Ref. | 1·332 | 0·894, 1·986 | 1·168 | 0·777, 1·754 | 1·151 | 1·052, 1·260 | 1·091 | 0·995, 1·196 |

DP, dietary pattern; HEI, Healthy Eating Index; SAFSSMC, Self-administered Food Security Survey Module for Children.
* Adjusted for child's sex, maternal education and caregivers' unemployment.

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12 % (OR = 1·119; 95 % CI: 1·006, 1·245), respectively, independently of maternal education, caregivers' unemployment and child's sex. No significant associations were observed considering the 'Intermediate consumption' DP.

## Discussion

Food insecure children exhibited a poor quality of diet, assessed by an adaptation of the HEI for children. Regarding the individual food groups included in the HEI, food insecure children had higher meat and meat products consumption and lower consumption of seafood and eggs, even after adjustments. When using the SAFSSMC raw score, associations between FI and lower fruit and vegetables and seafood and eggs consumption and with higher meat and meat products, salty snacks and soft drinks consumption were found, independently of maternal education, caregivers' unemployment and child's sex.

At 10 years old, five *a posteriori*-defined DPs were identified by latent class analysis: 'Healthier', 'Low consumption', 'Energy-dense foods', 'Snacking' and 'Intermediate consumption'. Food-insecure children were less likely to follow the 'Healthier' pattern, but no significant associations remained after adjustment for confounders. However, using the SAFSSMC raw score, positive associations with the 'Low consumption', 'Energy-dense foods' and 'Snacking' DPs were observed, independently of confounders.

Our findings are in agreement with previous research based on child FI reports, in which, FI showed to be inversely associated with HEI scores[5]. Furthermore, other studies using children reports of FI described that food-insecure children, compared with those food secure, had a higher consumption of fast food[8], sugar-sweetened beverages[17] and low vegetables consumption[6], which is in line with the findings of this study. FI has also been related to lower household consumption of meat and fruit, lower household diet diversity[34], as well as lower consumption of greens and beans and seafood[5]. Likewise, other studies pointed that food-insecure children had unhealthy food behaviours, namely eating more fast food, sweets and a higher intake of fat[8]. Also, higher consumption of salty foods, such as pizza and fried chicken, was reported among children from food-insecure households[35], corroborating our results.

Although Portuguese data on children FI and dietary intake are scarce, a study conducted in a convenience sample of households with children aged 6 to 8 years from a city of the Porto Metropolitan Area reported a lower frequency of consumption of fruit and vegetables and a higher frequency of consumption of sugar-sweetened beverages among children from food-insecure households[36], which is also in agreement with our findings. It is established that healthy diets are more expensive compared with the less healthy ones[37], which can support that food-insecure children had a lower diet quality and unhealthy DPs. Furthermore, usually mother is mainly responsible for the child's care[38]. Low maternal education has been associated with FI[39] and could also be related to low food literacy. Considering that food literacy is related to personal skills in, for instance, selecting, preparing, and eating healthy foods[40], this could somehow justify our findings that food-insecure children had lower quality of diet, even adjusted for variables that may represent the socio-economic status. Additionally, higher levels of stress have been associated with less healthy dietary behaviours[41]. Therefore, the psychological stress that could be caused by the children's FI situation may lead to higher consumption of unhealthy foods and inadequate food behaviours, corroborating our findings.

Concerning energy and nutrients, it has been reported that food-insecure children had higher energy[6] and sugar, fibre[6], fat intake[6,8] and a low intake of micronutrients, such as calcium and iron[42]. Also, a previous study[7] showed that very low food-secure children had greater energy intake. This could somehow sustain our findings, considering that food-insecure children had a poor diet quality, and a higher energy intake was observed in the first HEI tertile.

However, in the literature, no significant associations were reported[9] or only differences for few foods[35] according to the food security status categories was observed. Some reasons which could justify this: the use of the United States Household Food Security Survey Module: six-item short form has the limitation of not being able to capture the dimension of FI in children, being, mainly, a household measure[43]. Also, the use of parents/caregivers reports of food security status may not be representative of children's experiences of FI[12], affecting results of children's FI outcomes[34]. When using parents/caregivers reports, social desirability bias can affect the FI estimates, leading to underreporting. Moreover, the different methods used to analyse diet could contribute to the differences in the results[18].

Nevertheless, in two studies using child reports of FI and the same scale (five items from the Child Food Security Assessment), different results were obtained[5,6]. The use of different versions of the HEI (HEI-2005[6] and HEI-2015[5]) could eventually contribute to those discrepancies[44].

In our study, and using the food security status categories previously defined for Portuguese children[22], in the adjusted models, for some HEI food groups and for the *a posteriori*-defined DPs, no significant associations were obtained. On the other hand, using the SAFSSMC raw score significant associations were observed. As the direction of the associations was the same in both cases, the absence of statistical significance, when the two categories of food security status were used, probably happened due to lack of power due to the lower FI prevalence observed.

There are some additional limitations worth mentioning. First, the cross-sectional design of our study limits the inference about causality. Second, the FFQ questionnaire used to collect data on dietary intake was answered by the children's parents/caregivers. Therefore, it is possible that some foods, like those offered in school, were not accounted for. Third, the possibility of social desirability bias on the answers to the FFQ cannot also be discarded. Fourth, differences between the children evaluated at the 10-year-old follow-up included in this study and those not included were observed. However, considering the Cramer's V values[45], the effect was small, suggesting that these differences were due to the large sample size rather than due to differences between participants' characteristics, reducing the possibility of selection bias.

Nevertheless, this study was strengthened by the use of children self-reports of FI in studying the association between FI and dietary intake. Moreover, data on 3-d food diaries were used to calibrate the information of the FFQ, allowing, on the one hand, the use of the quantities of food consumption, and, on the other hand, overcame the overestimation of dietary intake in FFQ, as described in the literature[46]. Furthermore, and contrary to previous studies[5,6], we used as adjustment for potential confounders, not only children's individual characteristics but also characteristics related to the children's family environment that could influence both food security status and dietary intake, such as maternal education and caregivers' unemployment.

### Conclusions

FI was associated with worse dietary choices of 10-year-old children. Food-insecure children or those with higher SAFSSMC raw scores had a poorer diet quality, specifically a lower consumption of fruit and vegetables, seafood and eggs and higher consumption of meat and meat products, salty snacks and soft drinks. Children with a higher SAFSSMC raw score were more likely to have higher adherence to the 'Energy-dense foods', 'Low consumption' or 'Snacking' DPs when compared with those following the 'Healthier'.

In a public health context, intervention strategies targeting food-insecure children should be developed to promote healthy dietary habits in populations vulnerable to FI.

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I. M., A. O. and A. C. S. designed the study. I. M. and M. S. performed the statistical analysis. I. M. drafted the manuscript. All authors read, critically revised and edited the manuscript. All authors approved the final manuscript.

The authors declare that they have no conflicts of interest.

## Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114522001891

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