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Patterns of eating behavior among 13-year-old adolescents: findings from the Generation XXI birth cohort

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Padrões de comportamento alimentar em adolescentes de 13 anos: resultados da coorte de nascimentos da Geração XXI

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"Nós não somos máquinas:
somos seres vivos
com vontades,
sentimentos e
comportamentos alimentares."

Sophie Deram

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Como dizia **Guimarães Rosa**, "é junto dos bons, que ficamos melhores."

Muito obrigada!

Abstract

Lifestyles learned and adopted during adolescence may persist into adulthood, such as eating behavior. However, the literature exploring patterns of eating behavior and its determinants among adolescents remains limited. The aims of this study were to identify patterns of eating behavior in a sample of Portuguese adolescents and to explore whether the identified patterns differ in terms of early life characteristics, family environment, adolescent depressive symptoms level and BMI z-score. Participants were 3601 13-year-olds enrolled in Generation XXI, a population-based birth study. Adolescent eating behavior was assessed using the AEBQ, a self-reported questionnaire. The severity of depressive symptoms was measured through the BDI-II and data on sociodemographic and anthropometric characteristics were collected at birth and the 13-year-old follow-up. A person-centered approach, latent class analysis (LCA), was conducted, and associations were estimated using univariate and multivariable multinomial logistic regression models. Five patterns were identified, namely "Picky eating", "Disinterest towards food", "Food neophilia", "Emotional eating" and "Food approach", with distinct characteristics between them. BMI z-score, adolescent sex, depressive symptoms level and maternal education were significantly associated with the identified patterns. These findings suggest a starting point for such investigations into key subgroups, in order to help in the development and planning of targeted public health interventions.

Keywords: eating behavior; adolescents; depression; latent class analysis; environmental influences; weight

Resumo

Estilos de vida aprendidos e adotados durante a adolescência podem persistir na vida adulta, como o comportamento alimentar. Entretanto, a literatura que explora os padrões de comportamento alimentar e seus determinantes em adolescentes permanece limitada. Os objetivos principais deste estudo foram identificar padrões de comportamento alimentar em uma amostra de adolescentes portugueses e explorar se existiam diferenças entre os padrões identificados relativamente às características do início de vida, ambiente familiar, nível de sintomatologia depressiva em adolescentes e *z-score* de IMC. Participaram 3601 adolescentes de 13 anos de idade da Geração XXI, um estudo de base populacional de nascimento. O comportamento alimentar dos adolescentes foi avaliado por meio do AEBQ, um questionário de auto-relato. A severidade dos sintomas depressivos foi mensurada a partir do BDI-II e dados referentes às características sociodemográficas e antropométricas foram coletados ao nascimento e na avaliação de seguimento aos 13 anos. Realizou-se uma abordagem centrada no indivíduo, análise de classe latente (ACL), e associações foram analisadas por meio de regressão logística multinomial univariada e multivariada. Foram identificados cinco padrões, nomeadamente: "Comer exigente" ("Picky eating"), "Desinteresse pela comida", "Neofilia alimentar", "Comer emocional" e "Atração pela comida", com características distintas entre eles. *Z-score* de IMC, sexo, nível de sintomatologia depressiva e escolaridade materna apresentaram associação significativa com os padrões identificados. Estes achados sugerem um ponto de partida para investigações em subgrupos-chave, com o intuito de ajudar no desenvolvimento e planeamento de intervenções direcionadas ao nível de saúde pública.

Palavras-chave: comportamento alimentar; adolescentes; depressão; análise de classe latente; influências ambientais; peso

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List of Abbreviations

ACL: Análise de Classe Latente
AEBQ: Adult Eating Behavior Questionnaire
BDI-II: Beck Depression Inventory-II
BIC: Bayesian Information Criterion
BMI: Body Mass Index
BMIz: Body Mass Index z-score
CEBQ: Children's Eating Behavior Questionnaire
CI: Confidence Intervals
DEBQ: Dutch Eating Behavior Questionnaire
IMC: Índice de Massa Corporal
LCA: Latent Class Analysis
M: Mean
Md: Median
M_R: Mean Ranks
M_P: Mean Percentiles
n: Sample Size
OR: Odds Ratio
P: Percentiles
SD: Standard Deviations
UK: United Kingdom
WHO: World Health Organization

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1. Introduction

Adolescence is a transitional period from childhood into adulthood, marked by considerable physiological, psychological and social changes. Lifestyles learned and adopted during adolescence may persist into adulthood, such as eating behavior[1]. Eating behavior reflects the actions related to eating and include, for example, where, when and with whom we eat [2] and involve traits related to appetite, food acceptance and meal patterns[3]. As described in a previous study, one`s appetite is influenced by a complex gene-environment interaction[4].

Some eating behaviors are related with one`s greater interest towards foods and drinks, the so-called food approach behaviors, which are generally positively associated with body mass index (BMI)[5-9]. Other behaviors, the so-called food avoidant behaviors, are related with one`s avoidance or lack of interest towards foods and drinks, and are commonly negatively associated with BMI[5-9]. It is important to mention that opposite pathways may also be true, with BMI in childhood prospectively predicting, years later, greater scores on food approach and lower scores on food avoidant eating behaviors[10,11]. BMI may also predict greater disordered eating, such as binge eating, during adolescence[12,13].

Although these eating behaviors have shown to be moderately stable across childhood[14,15], Hunot-Alexander *et al*. (2019)[16] found that older adolescents (aged 14 to 18 years), compared to younger (aged 11 to 13 years), were more susceptible to external food cues and enjoyed food more, thus showing heightened food approach behaviors, which may enhance the risk of weight gain[15-17]. Although these behaviors may compromise adolescence health, the literature exploring patterns and trajectories of adolescent eating behavior remains limited.

Besides BMI, other relevant factors may also influence adolescent eating behaviors, such as mental health problems, given the fact that adolescence confers significant vulnerability to psychological problems[18]. Depression is a mental illness recognized as a leading cause of illness and disability among this population[19], and adolescents who are depressed may change their appetite and dietary patterns resulting in loss weight or leading to future weight gain and obesity[20-23].

A Chinese study[24], for example, demonstrated that emotional symptoms, such as depressive symptoms, increased the risk of restrained, emotional and external

eating in students aged 14 to 17 years, and individuals with higher BMI had an increased rate of restrained eating.

In adults, emotional eating has been pointed as one the possible mediators between depression, weight gain and obesity[25-27], but less is known about this association in adolescents[28]. It is important to mention that opposite pathways may also be true, with obesity increasing the risk for depression[23,29]. Studies also suggest a bi-directional association between depressive symptoms and eating disorders in adolescents, with depression increasing the risk of eating disorders[30,31] and eating pathology significantly predicting depression[32].

Additionally, familial environment could also affect, in a great extension, adolescent eating behaviors. A Chinese study[33] found that children and adolescents aged 7 to 12 years whose mothers had lower age, educational level and weight, tended to have a greater risk of developing picky eating behaviors, which is a behavior characterized by the rejection of a variety of both familiar and unfamiliar foods[34]. In another study with 9 to 12-year-old Finnish preadolescents[35], those who had siblings showed lower risk of being characterized as picky eaters.

Regarding family income, a Portuguese study[36] identified in a school-aged sample with 6 to 18 years that individuals with low-income backgrounds were more likely to overeat, a behavior characterized by consuming an objectively large amount of food[37], while most of the non-picky/non-over eaters were from medium/high-income families. Another study observed in an adolescent sample (aged 13 years) in the United Kingdom (UK) that low parental social class was associated with higher overeating scores in girls and lower food restriction scores in boys[38].

In childhood, researchers have associated characteristics in the beginning of life, such as low birth weight[39], preterm birth and lower fetal growth[40] with later eating difficulties and picky eating behavior pattern. In adolescents, little is known on how these early life characteristics may relate with later eating behavior patterns. It is plausible to assume that similar patterns may occur in adolescence, based on the evidence that eating behaviors are stable throughout childhood[14,15] and may persist through adolescence[16,41,42]; however research is necessary to confirm this hypothesis.

Considering the great amount of environmental influences on adolescent eating behaviors, and given the fact that studies in this field are still scarce, a deeper understanding of eating behavior patterns and its determinants among adolescents is warranted. The identification of eating behavior patterns could help in the identification of risk groups, and in the development and planning of public health interventions aiming to improve eating behavior throughout life and, consequently, to prevent excess weight gain.

In this sense, the aims of this study are (i) to identify patterns of eating behavior in a large sample of 13-year-old adolescents of an ongoing population-based cohort study, and (ii) to explore whether the identified patterns differ in terms of early life characteristics, family environment, adolescent depressive symptoms level and BMI z-score.

2. **Methods**

2.1 Study design and population

This study included participants enrolled in Generation XXI, an ongoing population-based birth cohort from Porto, northern Portugal. Recruitment took place between April 2005 and August 2006, and mothers were invited to participate in the study within 72 hours after delivery in all public maternities in the metropolitan area, through face-to-face interviews. Of all eligible mothers, 91% agreed to participate (8495 mothers and 8647 children at baseline). All families were invited for follow-ups at 4 (n = 7459, 86% of participation rate), 7 (n = 6889, 80% of participation rate), 10 (n = 6397, 76% of participation rate) and 13 years of age (n = 4643, 55% of participation rate – lower than expected due to the COVID-19 pandemic). Additional details about the recruitment and sample can be found elsewhere[43,44].

The current study included 3601 adolescents (77.6% of the participants at 13 years) with available data on self-reported eating behaviors and severity of depressive symptoms at the 13-year follow-up, and with other data of interest (see study flowchart in **Figure 1**).

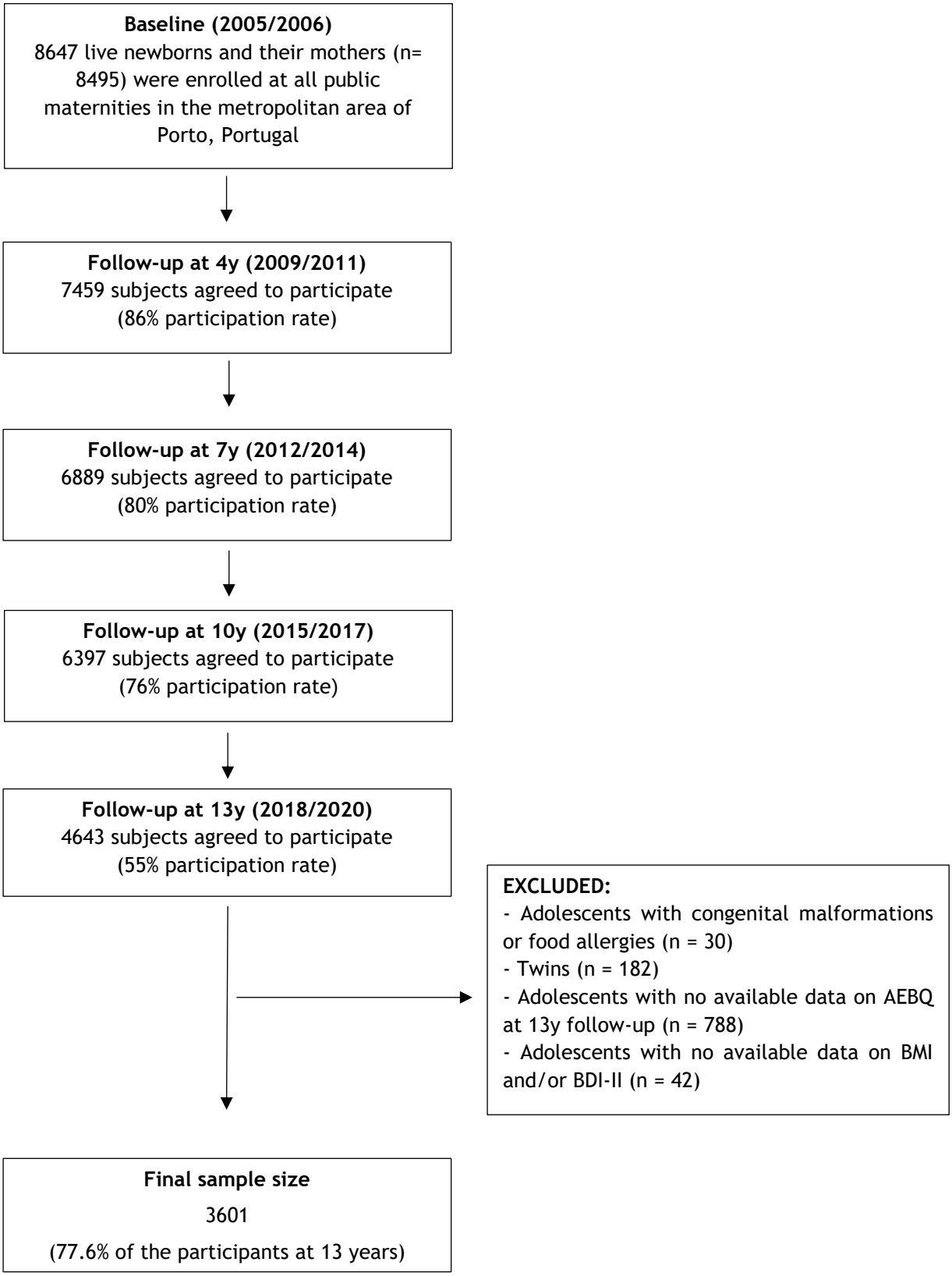


Figure 1. Flowchart of study participants from the Generation XXI birth cohort

Generation XXI was approved by the University of Porto Medical School/ S. João Hospital Centre Ethics Committee and by the Portuguese Data Protection Authority. All the phases of the study complied with the Ethical Principles for Medical Research Involving Human Subjects expressed in the Declaration of Helsinki. A written informed assent from the parents (or legal substitute) and oral consent from the children were obtained in each evaluation.

2.2 Measures

2.2.1 Adolescent self-reported eating behavior

Adolescent eating behavior was assessed at 13 years of age using a self-reported questionnaire, the Adult Eating Behavior Questionnaire (AEBQ). The AEBQ was originally developed by Hunot-Alexander *et al.* (2019)[16] based on the widely used Children's Eating Behavior Questionnaire (CEBQ)[45]. It contains 35 items, originally divided into eight subscales, conceptually grouped into food approach and food avoidance behaviors[16, 45-49].

The four AEBQ food approach subscales are Hunger (5 items, e.g. "I often feel hungry"), Food responsiveness (4 items, e.g. "I am always thinking about food"), Emotional overeating (5 items, e.g. "I eat more when I'm anxious") and Enjoyment of food (3 items, e.g. "I love food"). The remaining subscales, described as food avoidant dimensions, include Satiety responsiveness (4 items, e.g. "I often leave food on my plate at the end of a meal"), Emotional undereating (5 items, e.g. "I eat less when I'm worried"), Food fussiness (5 items, e.g. "I refuse new food at first") and Slowness in eating (4 items, e.g. "I eat slowly"). All items were responded using a 5-point Likert scale, ranging from 1 = "strongly disagree" to 5 = "strongly agree". Nonetheless, in accordance with the original scale, five of the items had reversed scoring[16].

In the original validation study in the UK, internal consistency was adequate for all AEBQ subscales (Cronbach's α ranging from 0.66 to 0.88)[16]. In Portugal, Warkentin *et al.* (2022)[49] recently validated the AEBQ among 13-year-old adolescents of Generation XXI cohort. The adapted version of the AEBQ contains 30 items and showed a different factor structure (5 subscales, namely Food responsiveness/Enjoyment of food, Emotional overeating, Slowness in eating,

Food fussiness and Emotional undereating), and an adequate internal consistency (Cronbach's α ranging from 0.77 to 0.89).

2.2.2 Depressive symptomatology level

The severity of depressive symptoms at 13 years old was measured using a validated updated version of the former Beck Depression Inventory (BDI)[50] that was originally proposed by Beck *et al.* (1961), namely the BDI-II[51].

The BDI-II is a 21-item self-report inventory, in which all items are rated on a 4-point Likert scale ranging from 0 to 3, and related to progressive gravity of specific symptoms (e.g. "I do not feel sad" (0), "I feel sad much of the time" (1), "I am sad all the time" (2) and "I am so sad or unhappy that I can't stand it" (3)). Adolescents were asked to select the best answer capable of describing how they had felt in the previous two weeks, including the day of the evaluation.

The total score, resulting from the sum of all items, ranges from 0 to 63. A score of lesser than or equal to 13 represents minimal depressive symptomatology, 14 to 19 represents mild depressive symptoms, 20 to 28 represents moderate depressive symptoms, and scores equal to or greater than 29 indicate severe depressive symptoms[51].

In Portugal, Coelho *et al.* (2002)[52] and Brochado *et al.* (2008)[53] investigated the BDI-II psychometric properties and the authors concluded that it appeared to be an adequate measure of depressive symptoms in adolescents, with a good internal consistency (Cronbach`s α = 0.89 in both studies).

2.2.3 Sociodemographic and anthropometric characteristics

Data on sociodemographic characteristics, such as maternal age, education, household monthly income, number of children, gestational age (according *to* ultrasound), weight for gestational age, and child sex, were collected at baseline through face-to-face interviews conducted by trained researchers using structured questionnaires. Weight for gestational age was classified according to the sex-specific population-based Kramer growth standards[54]. Small for gestational age was defined as below the 10th percentile, large for gestational age above the 90th percentile, and values within these thresholds were deemed to be adequate for gestational age. These references refer only to single births.

Maternal height and weight before pregnancy were self-recorded at birth, and BMI was calculated and classified according to the World Health Organization (WHO) cut-offs[55].

At the 13-year-old follow-up, data on the number of siblings who lived with the adolescent and respective ages were collected.

Adolescent anthropometrics, i.e., weight and height, were measured by trained staff, according to standard procedures. Adolescents were weighted in underwear and without shoes, by trained researchers, using a digital scale, and the measure was recorded to the nearest 0.1 kg. Height was also measured without shoes, using a fixed stadiometer, to the nearest 0.1 cm. These measures were used to calculate age- and sex-specific BMI z-scores, according to WHO[56]. Underweight was classified for those adolescents with BMI standard deviation scores (also called z-scores) < -2, normal weight for BMI z-scores in [-2; +1], overweight for BMI z-scores in]+1; +2] and obesity for BMI z-scores > +2.

2.3 Statistical analyses

Descriptive statistics were computed using means and standard deviations or medians and percentiles (P25; P75) for continuous variables, based on the distribution of the variables, and using frequency distribution for categorical variables. Data on the number of children (baseline) and the number of siblings who lived with the adolescent and respective ages (at 13-year-old follow-up) were combined and used to classify the adolescents as only child, the oldest sibling, a middle sibling, or the youngest sibling (classification of "birth order").

In this study, latent class analysis (LCA) was conducted using the procedure poLCA 1.4.1, in R 4.1.3 and RStudio 22.02.1. LCA belongs to the person- centered approaches, and it was used to identify patterns of eating behaviors among the 13-year-olds, based on responses given by the adolescents to the AEBQ (the adapted version with 30 items[49]). The central idea of the LCA is to recover hidden groups from observed data, being useful to reduce a large number of categorical variables to a few subgroups in which the observations are similar to each other but different from those in other subgroups [57,58].

In order to select the most robust and adequate number of latent classes, different values of classes (1 to 14) were evaluated, and the procedure was

repeated 100 times for each class. The most parsimonious number of latent classes was determined by examining the model fit, namely the Bayesian information criterion (BIC)[57]. Furthermore, an additional fit criteria was taken into account while choosing the class, namely the elbow heuristic for the BIC plot, that means finding the "elbow" of the plot, after which the decline in the value of these indicators reaches a plateau and becomes less noticeable, suggesting the optimal solution on elbow plot[59].

Resulting classes were compared in terms of the responses given by the adolescents to each item from the AEBQ, using Kruskal–Wallis test, and the mean ranks (m_R) were converted to mean percentiles (m_P) using the formula $m_P = 100\% * (m_R - 1) / (n - 1)$.

Univariate and multivariable multinomial logistic regression models were run, using IBM SPSS Statistics version 28.0 for Windows, to compute crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) estimating the association between the latent classes and adolescent sex, depressive symptomatology level, BMI z-score, weight for gestational age, birth order, maternal age, education and BMI before pregnancy, and household monthly income. Statistical significance was set at 5%.

3. Results

The total sample consisted of 3601 adolescents (approximately 51% were boys) with a median age of 13.3 years. Mean BMI z-score of participants was 0.44 (SD = 1.16) and nearly a third (33.1%) had excess weight (Overweight/Obesity). At baseline, family income was ≤ 1000 euros per month in 31.8% (n = 1010) of households, and mothers had, on average, 30.1 years old (SD = 5.0) and 11.3 years (SD = 4.3) of schooling.

Regarding depressive symptomatology level, 15% (n = 540) of adolescents showed mild to severe depressive symptoms. Further and more detailed sample characteristics are displayed in **Table 1.**

Table 1. Mother's and adolescent's characteristics at baseline and follow-up at 13y of age (n = 3601).

	Mean (SD) / Median (P25; P75)	***n (%)***
Maternal characteristics		
Age at baseline (years)	30.1 (5.0)	
Education at baseline (years of schooling)	11.3 (4.3)	
BMI before pregnancy (kg/m^2) *	23.0 (21.0; 25.8)	
Weight status before pregnancy (BMI)		
Underweight		107 (3.2)
Normal weight		2201 (65.5)
Overweight		750 (22.3)
Obesity		303 (9.0)
Household income (euros per month) [n = 3180]		
≤ 1000		1010 (31.8)
1001-2000		1591 (50.0)
> 2000		579 (18.2)
Birth characteristics		
Birth weight (g)	3225 (2950; 3510)	
Gestational age (weeks) [n = 3599]	39 (38; 40)	
Weight for gestational age [n = 3599]**		
Small		482 (13.4)
Adequate		2979 (82.7)
Large		138 (3.8)
Adolescent characteristics		
Sex		
Male		1831 (50.8)
Female		1770 (49.2)
Age (years)	13.28 (13.22; 13.39)	
BMI *z-score****	0.44 (1.16)	
Weight status (BMIz)		
Underweight		74 (2.1)
Normal weight		2334 (64.8)
Overweight		851 (23.6)
Obesity		342 (9.5)
Birth order		
Only child		1137 (31.6)
The oldest sibling		946 (26.3)
A middle sibling		192 (5.3)
The youngest sibling		1326 (36.8)
Adult Eating Behavior Questionnaire (AEBQ) - possible range 1 to 5		
Food Responsiveness/Enjoyment of Food	2.95 (0.64)	
Emotional Overeating	2.14 (0.79)	
Emotional Undereating	2.40 (0.94)	
Food Fussiness	2.77 (0.86)	
Slowness in Eating	2.62 (0.78)	
Beck Depression Inventory II (BDI-II)	5 (2; 10)	
Severity of depressive symptoms		
Minimal depressive symptomatology (range 0 to 13)		3061 (85.0)
Mild depressive symptoms (range 14 to 19)		318 (8.8)
Moderate depressive symptoms (range 20 to 28)		146 (4.1)
Severe depressive symptoms (range 29 to 63)		76 (2.1)

M: Mean, SD: Standard deviations, Md: Median, P: Percentiles, BMI: Body mass index, BMIz: Body mass index z-score. *Maternal weight status categories were defined according to the WHO Standards for BMI (kg/m^2): Underweight: BMI<18.5, Normal weight: BMI in [18.5; 25.0[, Overweight: BMI in [25.0; 30.0[, Obesity: ≥ 30.0 [55]. **Weight for gestational age was classified according to the Kramer Growth Standards, as follows: Small: < P10, Adequate: between P10 and P90, Large: > P90 [54]. ***Adolescent weight status categories were defined according to the WHO Growth Standards for BMIz, as follows: Underweight: BMIz < − 2, Normal weight: BMI in [-2; +1], Overweight: BMIz in]+1; +2], Obesity :BMIz > +2 [56].

3.1 Latent Class Analysis for the identification of adolescents eating behavior patterns

The model fit for 1 to 14 classes solutions was conducted. The lowest value of BIC supported the 10-class solution. However, according to the elbow plot, as shown in **Figure 2**, the 5-class solution showed to be the most adequate and parsimonious model, compared to the 10-class solution (albeit the gradually decreasing values of BIC up to 10 classes). Therefore, the 5-class or (5 patterns) solution was selected to best represent the current data.

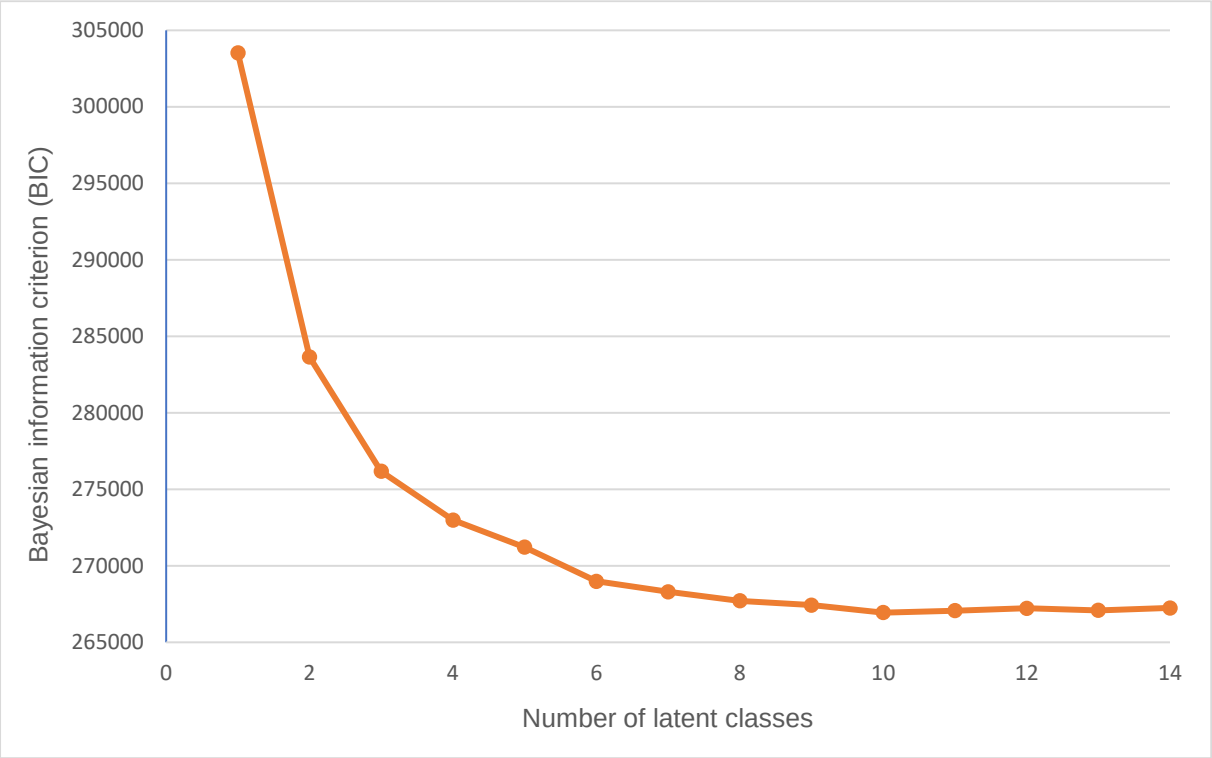


Figure 2. Elbow plot of the selected five patterns of eating behaviors among the 13-year-olds

Figure 3 graphically displays the characteristics of the five patterns of eating behaviors among the 13-year-olds.

The first pattern, accounting for 26.4% of the adolescents in this sample, was primarily characterized by the concordance with the items of Food fussiness (#2 “I often decide that I don’t like a food, before tasting it” and #7 “I refuse new foods at first”) and, at the same time, by the disagreement with the items #12 (“I enjoy tasting new foods”), #19 (“I am interested in tasting food I haven’t tasted

before") and #24 ("I enjoy a wide variety of foods") from the same subscale. They were also likely to disagree with the items #1 ("I love food") and #3 ("I love eating") from Food responsiveness/Enjoyment of food subscale and to agree with the items #29 ("I eat slowly") and #31 ("I get full up easily") from Slowness in eating subscale. This pattern was labeled "Picky eating", once the adolescents in this group were less likely to show an interest in trying novel and unfamiliar foods, besides they also showed a pattern of slow and joyless eating.

The second pattern, accounting for 25.5% of participants, was predominately described by the disagreement with all items that compose the Emotional overeating and Emotional undereating subscales, and with seven out of ten items from Food responsiveness/Enjoyment of food subscale (#4 "I look forward to mealtimes", #6 "I often notice my stomach rumbling", #13 "I often feel hungry when I am with someone who is eating", #17 "Given the choice, I would eat most of the time", #22 "I am always thinking about food", #28 "I often feel so hungry that I have to eat something right away" and # 32 "I often feel hungry"). Furthermore, they were also more likely to disagree with the items #26 ("I eat more and more slowly during the course of a meal"), #29 ("I eat slowly") and #31 ("I get full up easily") from the Slowness in eating subscale. Due to the disagreement with almost all subscales, except for the Food fussiness, that may indicate a less general interest in food, this group was labeled "Disinterest towards food".

Individuals in the third pattern, which accounted for 19.2% of this sample, in contrast to those adolescents in the first eating behavior pattern, were more likely to agree with the items #12 ("I enjoy tasting new foods"), #19 ("I am interested in tasting food I haven't tasted before") and #24 ("I enjoy a wide variety of foods") from the Food fussiness subscale. They were also likely to disagree with two items of the same subscale (# 2 "I often decide that I don't like a food, before tasting it" and #7 "I refuse new foods at first"), indicating that adolescents in this pattern were more likely to be willing to try novel foods; thus, this group was named "Food neophilia".

About 14.6% of adolescents in this study were assigned to the fourth pattern, in which adolescents were more likely to agree with the items of Slowness in eating subscale (#26 "I eat more and more slowly during the course of a meal"

and #31 “I get full up easily”). Nonetheless, this class was predominately described by the concordance with all items that compose the Emotional overeating and Emotional undereating subscales. Consequently, this group was labeled “Emotional eating”.

The fifth pattern included 14.3% of the adolescents, who were more likely to agree with the item #10 (“I eat more when I’m upset”) from Emotional overeating subscale. They were also likely to agree with the item #14 (“I often finish my meal(s) quickly”) from Slowness in eating subscale and to disagree with the items #29 (“I eat slowly”), #31 (“I get full up easily”) and #25 (“I am often last at finishing a meal”) from the same subscale. However, this group was predominately described by the concordance with all items that compose Food responsiveness/Enjoyment of food subscale, indicating that the eating behavior of the individuals in this pattern was more likely to be willing to suggest a movement toward or desire for food; thus, this class was labeled “Food approach”.

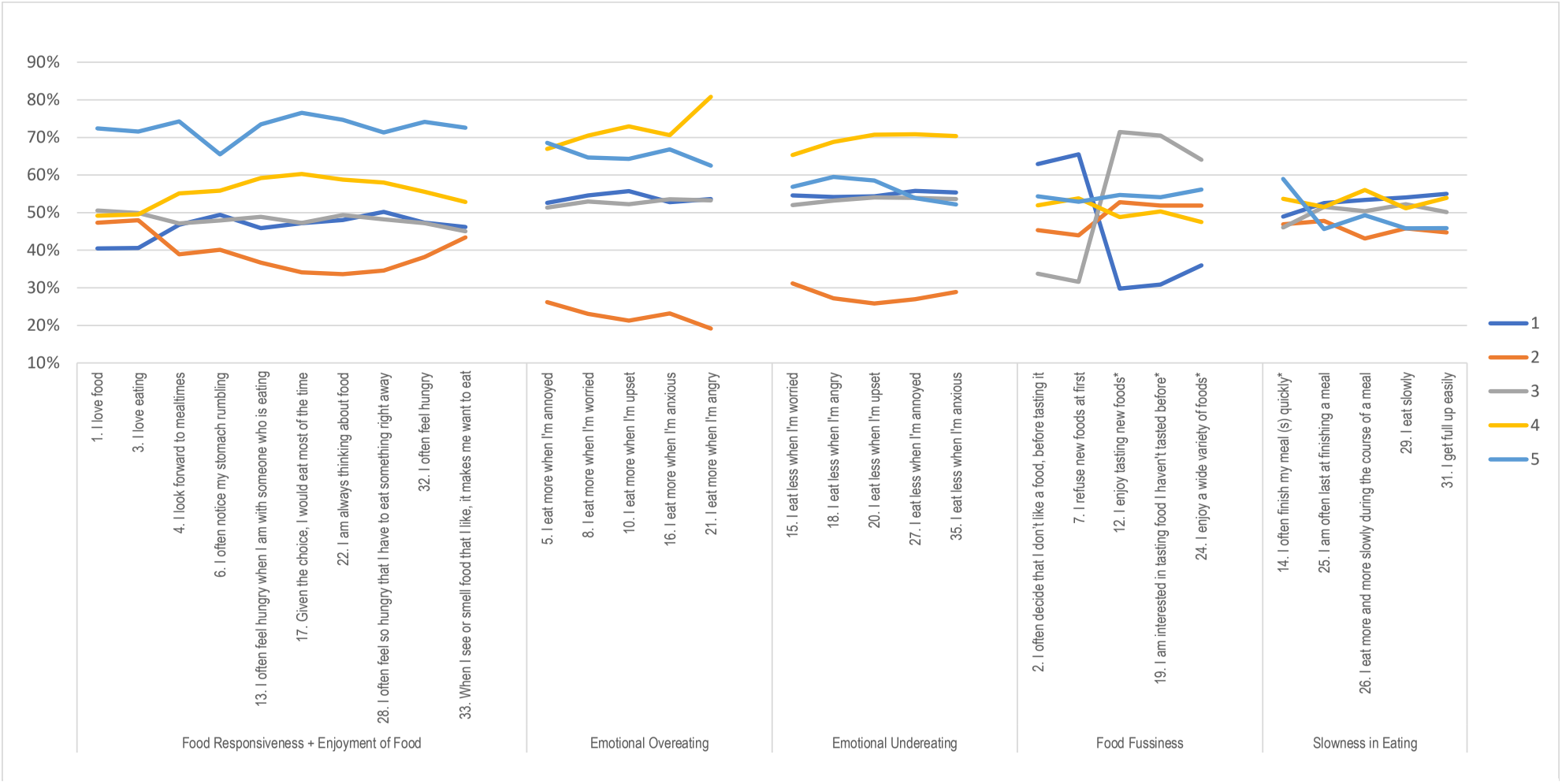


Figure 3. Visual description of the characteristics of the five adolescent eating behaviors patterns, according to the latent class analysis.

1: Picky eating (26.4%)

2: Disinterest towards food (25.5%)

3: Food neophilia (19.2%)

4: Emotional eating (14.6%)

5: Food approach (14.3%)

3.2 Associations between adolescent eating behavior patterns and sociodemographic and anthropometric characteristics

In **Table 2**, univariate multinomial logistic regression models between adolescent eating behaviors patterns, derived from the LCA, and various sociodemographic and anthropometric characteristics are described. Adolescents whose mothers had higher age at baseline and higher household income had lower chance of belonging to the "Food approach" group, compared to the reference pattern, the "Disinterest towards food" *(*Class 2*)*. However, in the multivariable multinomial logistic regression models, after further adjusting for maternal and adolescent characteristics, these associations were no longer significant (displayed in **Table 3** and **Table 4**, respectively).

Maternal education, adolescent sex, BMI z-score and depressive symptoms level showed to be significantly associated with the identified patterns of eating behaviors among the 13-year-olds **(Table 2)**, and these associations were maintained after further adjustments (**Table 3** and **Table 4**).

In the final adjusted model, compared to boys, girls were significantly more likely to fall into the "Picky eating", "Food neophilia", "Emotional eating" and "Food approach" patterns than into the reference category (+25%, +53%, +61% and +67%, respectively). Individuals with 1-unit higher BMI z-score were 18% more likely to be in the "Food neophilia" class, and those whose mothers had higher educational level were less likely to be in the latent class of "Food approach" (-6% per year of education), compared to the "Disinterest towards food" class. Adolescents with more severe depressive symptoms (higher scores on BDI-II) were more likely to belong to the "Picky eating" (+2%), "Emotional eating" (+5%) *and* "Food approach" (+10%) patterns than to the reference class.

No significant associations were found between eating behavior patterns and weight for gestational age, BMI before pregnancy or birth order.

Table 2. Univariate multinomial logistic regression showing associations between adolescent eating behavior patterns and adolescent and maternal sociodemographic and anthropometric characteristics (reference category: "Disinterest towards food" pattern (Class 2)).

	Univariate Model				
	p	**Class 1** **Picky eating**	**Class 3** **Food neophilia**	**Class 4** **Emotional eating**	**Class 5** **Food approach**
		OR [CI95%]			
Maternal characteristics					
Age at baseline	< 0.001	0.997 [0.979; 1.015]	0.995 [0.975; 1.015]	0.987 [0.966; 1.008]	**0.947 [0.927; 0.968]**
BMI before pregnancy	0.405	1.017 [0.994; 1.039]	1.001 [0.976; 1.025]	0.996 [0.970; 1.024]	0.995 [0.968; 1.022]
Household income (quantitative)	< 0.001	0.964 [0.900; 1.031]	1.015 [0.944; 1.091]	1.025 [0.948; 1.108]	**0.848 [0.778; 0.925]**
Education	< 0.001	0.984 [0.963; 1.005]	1.003 [0.980; 1.026]	1.013 [0.988; 1.039]	**0.927 [0.904; 0.951]**
Birth characteristics					
Weight for gestational age	0.098	0.906 [0.827; 0.992]	0.920 [0.833; 1.016]	0.876 [0.789; 0.972]	0.953 [0.854; 1.063]
Adolescent characteristics					
Sex (ref.: male)	< 0.001	**1.279 [1.065; 1.536]**	**1.614 [1.323; 1.970]**	**1.669 [1.344; 2.072]**	**2.137 [1.715; 2.661]**
BMIz	< 0.001	0.993 [0.919; 1.073]	**1.161 [1.066; 1.265]**	0.947 [0.864; 1.037]	1.055 [0.961; 1.157]
Weight for gestational age	0.098	0.906 [0.827; 0.992]	0.920 [0.833; 1.016]	0.876 [0.789; 0.972]	0.953 [0.854; 1.063]
Birth order (ref.: the youngest sibling)	0.063				
Only child		1.014 [0.816; 1.259]	0.979 [0.769; 1.245]	1.003 [0.770; 1.307]	1.025 [0.789; 1.333]
The oldest sibling		0.861 [0.682; 1.087]	1.092 [0.851; 1.401]	1.177 [0.898; 1.542]	0.969 [0.733; 1.280]
A middle sibling		1.089 [0.685; 1.731]	1.409 [0.871; 2.280]	1.681 [1.017; 2.778]	2.054 [1.273; 3.317]
Beck Depression Inventory II (BDI-II)	< 0.001	**1.028 [1.012; 1.045]**	**1.026 [1.008; 1.043]**	**1.054 [1.037; 1.072]**	**1.105 [1.088; 1.123]**

OR: odds ratio, CI: Confidence intervals, BMI: Body mass index, BMIz: Body mass index z-score. Bolded values are statistically significant ($p<0.05$).

Table 3. Multivariable multinomial logistic regression models showing associations between adolescent eating behavior patterns, sociodemographic and anthropometric characteristics (reference category: "Disinterest towards food" pattern (Class 2)).

	Adjusted Model 1				
	P	**Class 1** ***Picky eating***	**Class 3** ***Food neophilia***	**Class 4** ***Emotional eating***	**Class 5** ***Food approach***
		OR [CI95%]			
Maternal characteristics					
Age at baseline	0.159	1.001 [0.979; 1.023]	0.997 [0.974; 1.020]	0.986 [0.961; 1.012]	0.973 [0.948; 0.998]
BMI before pregnancy	0.291	1.013 [0.989; 1.038]	1.007 [0.980; 1.034]	0.997 [0.968; 1.027]	0.981 [0.952; 1011]
Household income (quantitative)	0.883	0.981 [0.897; 1.073]	1.013 [0.921; 1.114]	1.030 [0.930; 1.141]	0.980 [0.878; 1.094]
Education	< 0.001	0.992 [0.964; 1.021]	1.003 [0.972; 1.035]	1.014 [0.980; 1.049]	**0.931 [0.899; 0.965]**

OR: odds ratio, CI: Confidence intervals, BMI: Body mass index, BMIz: Body mass index z-score. Adjusted for maternal characteristics (age at baseline, BMI before pregnancy, household income and education). Bolded values are statistically significant ($p<0.05$).

Table 4. Multinomial logistic regression showing associations between adolescent eating behavior patterns and adolescent and maternal sociodemographic and anthropometric characteristics (reference category: "Disinterest towards food" pattern (Class 2)), adjusted for maternal characteristics plus adolescent characteristics – final model.

		Adjusted Model 2			
	p	**Class 1** ***Picky eating***	**Class 3** ***Food neophilia***	**Class 4** ***Emotional eating***	**Class 5** ***Food approach***
		OR [CI95%]			
Maternal characteristics					
Age at baseline	0.325	0.998 [0.974; 1.022]	1.001 [0.975; 1.027]	0.988 [0.960; 1.017]	0.973 [0.945; 1.001]
BMI before pregnancy	0.184	1.016 [0.990; 1.043]	0.991 [0.963; 1.019]	1.007 [0.975; 1.039]	0.980 [0.948; 1.013]
Household income (quantitative)	0.913	0.977 [0.893; 1.070]	1.005 [0.912; 1.107]	1.012 [0.912; 1.123]	0.964 [0.860; 1.081]
Education	0.005	0.995 [0.966; 1.025]	1.003 [0.971; 1.036]	1.017 [0.981; 1.053]	**0.943 [0.908; 0.979]**
Birth characteristics					
Weight for gestational age	0.354	0.919 [0.831; 1.016]	0.940 [0.842; 1.050]	0.899 [0.801; 1.009]	0.966 [0.851; 1.097]
Adolescent characteristics					
Sex (ref.: male)	< 0.001	**1.252 [1.019; 1.538]**	**1.527 [1.223; 1.906]**	**1.611 [1.265; 2.052]**	**1.672 [1.292; 2.163]**
BMIz	< 0.001	0.975 [0.889; 1.070]	**1.184 [1.069; 1.311]**	0.906 [0.811; 1.011]	0.978 [0.871; 1.097]
Birth order (ref.: the youngest sibling)	0.072				
Only child		0.989 [0.765; 1.277]	0.888 [0.669; 1.178]	0.889 [0.651; 1.214]	0.859 [0.622; 1.188]
The oldest sibling		0.914 [0.682; 1.225]	1.111 [0.813; 1.518]	1.122 [0.799; 1.574]	0.915 [0.635; 1.320]
A middle sibling		1.136 [0.674; 1.915]	1.509 [0.880; 2.587]	1.934 [1.118; 3.346]	2.074 [1.186; 3.628]
Beck Depression Inventory II (BDI-II)	< 0.001	**1.022 [1.004; 1.041]**	1.019 [1.000; 1.038]	**1.052 [1.033; 1.072]**	**1.098 [1.079; 1.118]**

OR: odds ratio, CI: Confidence intervals, BMI: Body mass index, BMIz: Body mass index z-score. Adjusted for Model 1 (maternal characteristics) plus adolescent characteristics (adolescent sex, BMIz, birth order and depressive symptoms level). Bolded values are statistically significant ($p<0.05$).

4. Discussion

To our knowledge, this study is the first to characterize eating behavior patterns in a large sample of 13-year-old Portuguese adolescents of an ongoing population-based cohort study, using latent class analysis, a person-centered approach. Five patterns were identified, namely "Picky eating", "Disinterest towards food", "Food neophilia", "Emotional eating" and "Food approach", with distinct characteristics between them. We found that BMI z-score, adolescent sex, depressive symptoms level and maternal education were associated with the identified patterns.

Among the five eating behavior patterns, about 26.4% of adolescents were assigned to the "Picky eating" class, which has a similar frequency rate to the one observed in another Portuguese study[36] that found a picky eating frequency of 23.1% in a school-aged sample with, on average, 10.8 years of age. Our finding may suggest that picky eating behavior was relatively frequent in this age group, although picky eating has been reported, in most cases, as a transient behavior, having the highest prevalence around the age 2 years, followed by a decline until 6 years of age[60-62]. However, there is also evidence that this eating behavior can be found across the whole lifespan, from childhood through adulthood[41,61,63,64], which is in line with our finding.

While it is well established that some degree of picky eating is considered a part of normal child development, not necessarily warranting clinical attention, little is known on how this behavior may impact diet, growth and health outcomes[65]. In a study conducted by Herle *et al.* (2019)[41], for example, the authors found associations between picky eating behaviors in childhood and an increased risk of developing anorexia nervosa later in life. The mechanisms behind this association are still unknown and future research is necessary.

In addition, it is important to mention that individuals in the "Picky eating" pattern, in this current study, besides showing a lower interest in trying novel and unfamiliar foods, were also less likely to enjoy eating and a variety of foods and showed a greater tendency to eat slower and get full more easily. This finding was similar with that reported in the study conducted by De Barse *et al.* (2015)[66], in which, using CEBQ's scales, a pattern was identified with children who were more likely to reject certain types of foods, *and* who also showed a pattern of slow and

joyless eating. Nonetheless, the authors suggested that the combination of those behaviors could reflect a more "severe" fussy eating pattern (another form to refer to 'picky' eating), once they found that this pattern may result in a possible adverse effect on healthy growth, associated with the risk of developing underweight and a relatively low fat-free mass in children.

Thus, further attention to the "Picky eating" pattern found in our study is warranted. Additional research may help to identify whether subpopulations exist within picky eating profiles that are clinically important to differentiate.

In this current study, we found that adolescents with higher BMI z-score were more likely to belong to the "Food neophilia" pattern (18%). This association was unexpected, since usually children and adolescents in heavier weight groups are more likely to show emotional eating[12,67-71], food responsiveness and enjoyment of food behaviors[12,69-71].

However, considering that neophiliac individuals tend to like and approach new foods[72], indicating an eating behavior that involves a movement towards or desire for food, it is plausible that the food neophilia trait may relate with food approach eating behaviors as well. Previous studies have suggested that food approach behaviors are positively related to one another[16,73], being generally positively associated with BMI[5-9,70], which may justify our result.

Furthermore, research on food neophilia and its possible health effects remains limited[74]. On the other side, there is a vast amount of information on food neophobia (the tendency to avoid or refuse novel or unfamiliar foods), considered to be a specific component of picky eating behavior[33,65,74-78].

However, the majority of studies found no significant associations between food neophobia and weight status, and in adolescence the literature is also quite sparse[65,74,75]. In a systematic review[75], examining the association between food neophobia and weight status, just one out of seven studies found a positive association with overweight, contradicting our finding[79]. Nevertheless, the age group was not the same than our sample (children aged 2 to 6 years).

It is important to mention that individuals in the "Food neophilia" pattern, besides being more likely to show an interest in trying novel and unfamiliar foods, were also more likely to enjoy a wide variety of foods. Nonetheless, dietary variety has been recognized as a paradox[80]: although the consumption of a variety of

food items has been recommended to promote an adequate nutrient intake[81], studies have also associated dietary variety with a higher energy intake and weight gain[82,83]. The idea of variety and diversity may lead to the inclusion of unhealthy foods in the diet, increasing, consequently, the intake of energy, processed foods, sugar-sweetened beverages and refined grains[82,83].

In the current study, the association between the "Food neophilia" pattern and energy intake was not investigated; however, there might be another explanation for the association found between the "Food neophilia" class and adolescents with higher BMI z-score. This may be considered a starting point for future research, aiming to examine associations between the AEBQ subscales and measures of food preferences, intake and diet quality in adolescents. Moreover, further studies are also warranted aiming to clarify the association between individuals with "Food neophilia" eating pattern and potential health outcomes.

Regarding sex, we found that some patterns, such as "Picky eating", "Food neophilia" and, especially, "Emotional eating" and "Food approach" included mainly girls (25%, 53%, 61% and 67% more, respectively). Contrarily to our findings, Loh *et al.* (2013)[84], using CEBQ subscales, found no significant differences in eating behaviors between Malaysian adolescent boys and girls, while Santos *et al.* (2011)[6], observed in a sample of Chilean children (6 to 12 years old) significantly higher scores for food avoidant subscales (Slowness in eating, Satiety responsiveness and Emotional under-eating) in girls, compared to boys.

Nonetheless, Hunot-Alexander *et al.* 2019[16] comparing adolescents aged 11 to 18 years, reported that girls showed higher scores on Emotional overeating, Satiety responsiveness and Slowness in eating. Consistent with these findings, a Polish study observed, in a sample of secondary school students, that girls, besides reported higher levels of Emotional overeating, Satiety responsiveness and Slowness in eating, also showed higher scores of Food responsiveness and Emotional undereating[73]. In both studies, boys did not show higher scores for any of the subscales, which is in line with our findings, wherein boys showed to be more likely to disagree with almost all dimensions[16,73].

In a Chinese study[58] with 1068 young adults, using LCA, the authors observed that women, compared to men, were more likely to be in the patterns of "Emotional overeating" and "Emotional over- and undereating". This "Emotional

over- and undereating" was a mixed pattern of individuals identified with both emotional over-under-eating. According to the authors, it was considered the most problematic pattern, with the highest level of eating disorder symptoms and psychological distress. The possible explanation for this finding was that individuals in this class may be more likely to have difficulties in emotional regulation, which also can result in more eating disorders symptoms[58].

Interestingly, we also found a mixed pattern in our study, namely "Emotional eating", wherein, as previously mentioned, adolescents were more likely to both overeat *and* to undereat in response to emotions. In line with our finding, a cohort study of 4-year-old British twins[85] found that the Emotional overeating and Emotional undereating subscales from CEBQ were correlated positively, also indicating that some children tend to both over-eat and under-eat, as a response to emotions and stress.

The identification of such a mixed pattern suggests that emotional over- and undereating could be two unique constructs that may co-occur among individuals [58]. However, the explanation regarding emotion regulation should be explored in future studies, as well as a better understanding of the "Emotional eating" pattern and its characteristics. Furthermore, more comprehensive understanding of sex differences for certain eating behaviors in adolescence are needed, using the subscales of the more recent and validated AEBQ.

In the current study, the prevalence of adolescents with mild to severe depressive symptoms was 15%, higher than the frequency rate observed in another Portuguese study[86], which reported 11.9% among adolescents with the same age. Besides, we found that adolescents with higher scores on BDI-II had higher risk of belonging to the "Picky eating" (+2%) and, especially, "Emotional eating" (+5%) and "Food approach" (+10%) patterns.

This association may be explained partly by the fact that individuals with depressive symptoms have dysfunctional coping strategies that can lead to the developing of abnormal eating behaviors, such as emotional eating, wherein food is used as a natural reward or gratification habit for alleviating and dealing with stress and negative feelings[87-89].

Different studies have suggested an association between emotional eating and higher depressive symptoms[25,89-91]. In an Australian study[92], for example, the

authors found that adolescents (aged 10 to 13 years) who reported more emotional eating, concurrently reported higher depressive symptoms. For that reason, we expected that the "Emotional eating" pattern would include adolescents with the highest scores on BDI-II. Besides, considering that the "Emotional eating" was a mixed pattern, as stated above, supposedly the individuals in this class could have difficulties to regulate their emotions.

Nonetheless, it has also been reported that some individuals, in order to shift attention away from negative feelings, such as depressive feelings, may focus their attention at the current and immediate environment stimulus, as accessible food cues, for example[27,93]. Considering that the "Food approach" pattern included adolescents who were more likely to response to external food cues, it may justify the association found between this pattern and adolescents with more severe depressive symptoms in our study. However, further studies are necessary to examine this possible link, using measures that specifically address adolescent's responsiveness to external cues, such as visual, environmental, or social cues.

Lastly, we found that adolescents whose mothers had higher educational level were less likely to be in the latent class of "Food approach". Contrary to this finding, in a study to validate the AEBQ for UK adolescents[16], no association between maternal education and adolescent eating behavior was observed. In another study with school-age children in China[33], the authors found that mothers of picky eaters had lower educational level compared to mothers of non-picky eaters. Moreover, they suggested that mothers with higher educational level may be more concerned about the children's eating behaviors and may provide them healthier foods[33].

However, in agreement with the current result, a previous study explored the differences between children's eating behaviors (aged 6 to 10 years) and their relationship with maternal education level, and it was observed that individuals whose mothers with a bachelor's degree or graduate level education, compared to those with a lower education level, showed significantly decreased in the Food responsiveness subscale from CEBQ[94].

In addition, a study with Chinese students aged 11 to 13 years[24], using the Dutch Eating Behavior Questionnaire (DEBQ)[95], showed that higher levels of parental education and family income were associated with higher levels of

restrained eating (the tendency to restrict food intake aiming to control the body weight). Considering that the DEBQ Restrained eating subscale is related with undereating, it is likely to be inversely related to the AEBQ food approach dimensions, confirming our result.

It is important to note that, besides this association between "Food approach" class and maternal educational level, this pattern, as we had mentioned before, was also associated with higher score of depressive symptoms. Interestingly, a previous study conducted with children and adolescents showed that participants whose mothers had higher levels of education reported less mental health problems compared with those of mothers with lower education[96]. This finding is consistent with that reported in a study carried out in Canada on participants aged 12 to 24 years, wherein maternal low education (mothers with less than secondary school education) was associated with an increased risk of depressive episodes among their offspring[97].

Furthermore, starting puberty, girls are at the greatest risk for depression, with higher prevalence compared to boys[98,99]. In this current study, as described above, the "Food approach" pattern was also 67% more likely to have girls. Thus, these associations that we found with these potential risk factors, emphasize that a further attention to this pattern is warranted. Indeed, more research is also required to obtain a thorough understanding of the effects of maternal educational levels on adolescent eating behavior.

The association between the identified patterns of eating behaviors and maternal age and household income was only significant in univariate analysis and showed that adolescents whose mothers had higher age at baseline and higher household income had lower chance to belong to the "Food approach" group. These findings were unexpected, since household income and maternal education are indicators of socioeconomic status commonly applied in researches and are usually highly correlated[100]. In addition, it has been reported that young mothers may tend to have lower socioeconomic status and less schooling than older ones[101].

Our results also showed no significant association between eating behavior patterns and weight for gestational age, BMI before pregnancy and birth order,

and to the best of our knowledge, our study has been the first to explore the association between these variables and AEBQ's scales in adolescence.

Previously, Omar *et al.* (2022)[102], using CEBQ's scales, explored for the first time the relationship between eating behavior and birth status (preterm/full-term) among primary school children aged 5 to 14 years. They observed that full-term children reported higher levels of Enjoyment of food and Desire to drink, while preterm children showed higher levels of Slowness in eating and Satiety responsiveness. However, gestational age and BMI before pregnancy were not included in the analysis. Regarding birth order, contrary to our finding, a study with a sample of 5- to 11-year-old children, observed that having siblings was associated with faster eating rate and first-borns were more likely to eat faster than those who were not first-born[103].

Thus, due the discrepancy in these findings and given the fact that studies in this field are still scarce, further investigation into these characteristics, using the AEBQ subscales, may bring some insight to understand the effects of these environmental factors on adolescent eating behavior.

The current study has some limitations that need to be addressed. Firstly, adolescent eating behavior was assessed using a self-reported questionnaire, which may have affected results, due to the vulnerability to social desirability bias. Some eating behaviors, such as Food responsiveness, may not be admitted or may be perceived as less desirable than others by adolescents, leading to their underreporting[16,49]. While other behaviors, such as Slowness in eating, may be seen as more favorable, being over-reported[16,49].

Additionally, other aspects that may have influenced adolescent eating behavior were not included in the current study, such as food preferences, intake, and diet quality. Finally, depressive symptoms score was also obtained by a self-report questionnaire, which may be affected by social desirability bias as well. Furthermore, this measure does not permit a diagnostic assessment of depression as would a clinical interview.

However, the strengths of this research lie in the use of a large sample size, in the execution of standardized assessments and the inclusion of objectively measured weight and height in adolescents. In addition, AEBQ was recently validated in Portuguese adolescents, providing a convenient and easy-to-use tool

in this age group in large-scale research[49]. BDI-II is considered a reliable and well-validated adolescent report as well[104]. It is important to highlight that, using a person-centered approach (LCA), our study was able to identify the existence of an unobserved subgroup with individuals with both emotional over-eating and emotional under-eating, which it should be explored in further investigations.

5. Conclusion

In conclusion, using LCA, the current study identified five distinct patterns of eating behavior in a large sample of 13-year-old adolescents of an ongoing population-based cohort study: “Picky eating”, “Disinterest towards food”, “Food neophilia”, “Emotional eating” and “Food approach”. Maternal education, adolescents’ sex, BMI z-score and depressive symptoms level showed to be significantly associated with these patterns. Considering the great amount of environmental influences on adolescent eating behaviors, our findings suggest a starting point for such investigations into key subgroups, in order to help in the development and planning of targeted public health interventions. Given the novelty of these findings, future research is needed to clarify whether these eating behavior patterns are associated with health outcomes.

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Patterns of eating behavior among 13-year-old adolescents: findings from the Generation XXI

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