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# Adverse childhood experiences and dietary patterns of 10-year-olds: evidence from a prospective birth cohort

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**Adverse childhood experiences and dietary patterns of 10-year-olds: evidence from a prospective birth cohort**

Experiências adversas na infância e padrões alimentares de crianças de 10 anos de idade: evidência de uma coorte de nascimento prospetiva

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**Abstract**

**Introduction:** Childhood is a critical period of development, and adversity experienced during this life stage is known to have long-term health effects. Previous literature has shown that adverse childhood experiences (ACEs) are a modifiable risk factor for numerous chronic diseases including depression, cardiovascular disease, diabetes, and obesity. Although the association between ACEs and several health-risk behaviours in adulthood is well established, the evidence of their effects on diet, particularly at young ages, is very scarce.

**Objective:** This study aims to investigate the association between ACEs (by dimensions and number of adverse events across childhood) and the dietary patterns at 10 years old.

**Methods:** Data from the population-based birth cohort Generation XXI was used. Participants were recruited at birth between 2005 and 2006 in the public maternity units from Porto (n=8647), and invited to participate in the follow-up evaluations at 4, 7 and 10 years of age. In this study, 5034 children evaluated at birth and at the 10-year-old follow-up were included. A self-administered questionnaire was used to retrospectively assess children's exposure to ACEs, which were grouped into 5 dimensions by principal component analysis: "abuse", "school problems", "death/severe disease", "life changes", and "household dysfunction". Food consumption was measured through a validated Food Frequency Questionnaire and dietary patterns were identified by latent class analysis. Five dietary patterns were studied: "low consumption", "energy-dense foods", "snacking", "intermediate consumption", and "healthier" (used as reference). Multinomial regression analyses were performed, and models were

adjusted for household income, family structure and mother's age. Results are presented as *odds ratio* and the respective 95% confidence intervals (OR, 95%CI), with sex stratification.

**Results:** Overall, 96% of children reported having been exposed to at least one ACE, and the percentage of those reporting 6 or more ACEs was 31.6% and 21.1% respectively in boys and girls. The most prevalent ACEs were a household member shouting, yelling, or screaming at the child (57.9%), witnessing parents arguing or fighting (44.4%), and the death of a family member or close friend (43.4%).
In girls, ACEs under the dimensions of "abuse" and "death/severe disease", were associated with increased odds of following less healthy dietary patterns, such as the "low consumption" (OR=1.44, 95%CI = 1.12-1.85 and OR=1.62, 95%CI = 1.18-2.23, respectively) and the "energy-dense foods" (OR=1.37, 95%CI = 1.07-1.71 and OR=1.41, 95%CI = 1.04-1.92, respectively). In boys, only the total sum of ACEs was associated with dietary patterns. Children reporting a sum of ACEs (≥ 6 ACEs), compared with no ACEs, were at 2-fold increased odds to follow the "low consumption" (OR=1.97, 95%CI = 1.00-3.87) and at 4-fold increased odds to follow the "energy-dense foods" dietary pattern (OR=3.83, 95%CI = 1.27-11.55).

**Conclusion:** An association between exposure to ACEs and less healthy dietary patterns was observed. Differences between sexes were found, suggesting that girls are more susceptible to deviate from a healthy dietary pattern when exposed to abuse or traumatic events, and in boys the total number of experiences was associated with a diet higher in energy-dense foods, and with lower food consumption. These findings highlight the need of prevention and intervention actions that can reduce exposure to ACEs and its consequences, namely in diet.

***Keywords:*** *Feeding behaviour; Diet; Adverse experiences; Cohort studies; Childhood*

**Resumo**

**Introdução:** A infância é um período crítico de desenvolvimento e as experiências adversas vividas durante esta fase têm efeitos na saúde a longo prazo. A literatura existente indica que as experiências adversas na infância são um fator de risco modificável para inúmeras doenças crónicas, incluindo a depressão, as doenças cardiovasculares, a diabetes e a obesidade. Embora a associação entre as experiências adversas na infância e vários comportamentos de risco para a saúde na idade adulta esteja bem estabelecida, a evidência dos seus efeitos na alimentação, particularmente na infância, é escassa.

**Objetivo:** Esta dissertação tem como objetivo investigar a associação entre experiências adversas (por dimensões e número de eventos adversos ao longo da infância) e os padrões alimentares aos 10 anos de idade.

**Métodos:** Dados da coorte de nascimento Geração XXI foram usados para esta dissertação. Os participantes foram recrutados ao nascimento entre 2005 e 2006 nas maternidades públicas do Porto (n=8647), e convidados a participar nas avaliações de seguimento aos 4, 7 e 10 anos de idade. Neste estudo, foram incluídas 5034 crianças avaliadas ao nascimento e aos 10 anos. Um questionário auto-aplicado à criança avaliou retrospetivamente a exposição a experiências adversas na infância, posteriormente agrupadas em 5 dimensões por análise de componentes principais: “abuso”, “problemas na escola”, “morte/doença severa”, “mudanças de vida”, “disfunção doméstica”. O consumo alimentar foi avaliado através de um Questionário de Frequência Alimentar validado e os padrões alimentares foram identificados por análise de classes latentes. Cinco padrões alimentares foram definidos: “baixo consumo”, “alimentos densamente

energéticos", "consumo entre refeições (*snacking*)", "consumo intermédio" e "mais saudável" (usado como referência). Análises de regressão multinomial foram realizadas e os modelos foram ajustados para rendimento do agregado familiar, estrutura familiar e idade da mãe. Os resultados são apresentados como *odds ratio* e respetivos intervalos de confiança a 95% (OR, IC 95%), com estratificação pelo sexo da criança.

**Resultados:** Globalmente, 96% das crianças reportaram ter sido expostas a pelo menos uma experiência adversa na infância, e a percentagem que referiu 6 ou mais eventos adversos foi de 31,6% e 21,1%, respetivamente em rapazes e raparigas. As experiências adversas na infância mais prevalentes foram um membro da família gritar, ou berrar com a criança (57,9%), presenciar discussões entre os pais (44,4%) e a morte de um familiar ou amigo próximo (43,4%). Nas raparigas, as experiências adversas na infância nas dimensões de "abuso" e "morte/doença grave" foram associadas a uma maior probabilidade de seguir padrões alimentares menos saudáveis, como os caracterizados por "baixo consumo" (OR=1,44, IC95% = 1,12-1,85 and OR=1,62, 95%CI = 1,18-2,23, respetivamente) e "alimentos densamente energéticos" (OR=1,37, 95%CI = 1,07-1,71 and OR=1,41, 95%CI = 1,04-1,92, respetivamente). Nos rapazes, apenas o somatório total de experiências adversas foi associado aos padrões alimentares. As crianças que reportaram uma soma de eventos ≥ 6, em comparação com nenhuma experiências adversa, tiveram uma probabilidade duplicada de seguir o padrão alimentar de "baixo consumo" (OR=1,97, 95%CI = 1,00-3,87) e 4 vezes mais probabilidade de seguir o padrão alimentar caracterizado por um consumo mais elevado de "alimentos densamente energéticos" (OR=3,83, 95%CI = 1,27-11,55).

**Conclusões:** Observou-se uma associação entre a exposição a experiências adversas na infância e padrões alimentares genericamente menos saudáveis. Foram encontradas diferenças entre os sexos, sugerindo que as raparigas são mais suscetíveis a desviar-se de um padrão alimentar saudável quando expostas a abusos ou eventos traumáticos. Nos rapazes, o número total de experiências foi associado a um padrão alimentar mais rico em alimentos altamente energéticos e com um consumo alimentar total reduzido. Estes resultados realçam a necessidade de ações de prevenção e intervenção que possam reduzir a exposição às experiências adversas na infância e às suas consequências, nomeadamente nos padrões alimentares.

***Palavras-Chave:*** *Comportamento alimentar; Alimentação; Experiências adversas; Estudos de coorte; Infância*

**Índex**

**Abbreviations and acronyms**

ACEs - Adverse childhood experiences

BMI - Body mass index

CI – Confidence interval

CASE - Child and Adolescent Survey of Experiences: Child Version

CDC - Centers for Disease Control and Prevention

ED – Eating disorders

FCT - Foundation for Science and Technology

FFQ - Food frequency questionnaire

HEI-10 - Healthy Eating Index-2010

IQR – Interquartile range

LCA – Latent class analysis

OR – Odds ratio

PCA - Principal component analysis

SPSS - Software Package for Social Sciences

SD – Standard deviation

SES - Socioeconomic status

U.S. – United States of America

WHO - World Health Organization

**Figure index**



**Figure index of the Manuscript**



**Table index**



**Table index of the Manuscript**

# 1. Introduction

## 1.1. Adverse Childhood Experiences: definition and prevalence

According to the World Health Organization "*Adverse Childhood Experiences (ACEs) refer to some of the most intensive and frequently occurring sources of stress that children may suffer early in life*" [(1)]. These experiences may include different types of abuse, neglect, or violence within the family environment, other household dysfunctions, such as alcohol and substance abuse, and exposure to peer, community, and collective violence [(1)].

The term ACEs was firstly coined by Felitti et al. in 1998, following the publication of the Adverse Childhood Experiences study (ACE study), conducted in partnership with the Centers for Disease Control and Prevention (CDC) [(2)]. The researchers collected data from a large sample of American adults aiming to understand the impact of childhood adversity on several health outcomes. ACEs were grouped into 3 domains: abuse, neglect, and household dysfunction, composed by 10 sub-categories of adverse experiences [(2)]. In Table 1, these domains and sub-categories are described.

**Table 1.** Types of adverse childhood experiences (Adapted from: Centers for Disease Control and Prevention) [(12)]

| *Types of Adverse Childhood Experiences* |
|---|
| **ABUSE** |
| **Physical** - A parent or adult in home hit, pushed, grabbed, slapped, or threw something at you. |
| **Emotional** - A parent or adult in home swore at you, insulted you, or put you down. |
| **Sexual** - An adult, relative, or stranger, at least 5 years older, ever touched you in a sexual way, made you touch his/her body, or attempted to have sex with you. |
| **NEGLECT** |

| |
|---|
| **Physical** – Someone in your family never or rarely helped you feel important or loved, people in your family never looked out for each other, or was never a source support |
| **Emotional** – There was never someone to take care of you, and take you to the doctor if you needed it, you didn't have enough to eat, or you had to wear dirty clothes |
| **HOUSEHOLD DYSFUNCTION** |
| **Mental illness** - A household member was depressed, mentally ill, or attempted suicide. |
| **Incarcerated Relative** - A household member went to prison. |
| **Mother treated violently** - Mother or stepmother was pushed, grabbed, had something thrown at her, was kicked, bitten, threatened or hurt by her partner. |
| **Substance misuse** - A household member was a problem drinker, alcoholic or used street drugs |
| **Divorce** - Parents were ever separated or divorced. |

In the original ACE study, approximately half of the respondents (mean age= 56.1 years) reported having experienced at least one ACE during childhood (52.1%) [(2)]. Another study in the U.S. observed that 57.7% of the children and youth had experienced or witnessed at least one ACE in the year before the survey, and concluded that when an individual experiences one ACE, there is an increased likelihood of experiencing another [(3)].

In Europe, few studies have addressed the prevalence of ACEs and those were mainly focused on physical and sexual forms of abuse. In high income countries, every year around 4-16% of children are physically abused and 10% is neglected. The prevalence of sexual abuse is estimated to affect between 5% and 10% of girls and up to 5% of boys during childhood [(4)]. In Portugal, child maltreatment was assessed in a sample of adults using the *Childhood Trauma Questionnaire-Short Form* [(5)]. The prevalence of self-reported moderate or severe child maltreatment exposure was 14.7%, and 67% of the participants was exposed to more than one form of maltreatment. Authors concluded that emotional neglect was the most common form of child maltreatment, while emotional abuse was also highly

reported and showed the largest correlations with psychological symptoms. Comparing with other countries, such as United States or Germany, physical abuse and sexual abuse were less reported in Portugal [5].

When assessing sex differences, the same study with Portuguese adults suggested that women are more likely to be exposed to emotional abuse and men to physical abuse [5]. Dube and colleagues (2006) have observed a prevalence of ACEs generally higher in women than men, except for physical abuse and physical neglect [6]. Similar to these conclusions, in a sample of 4503 U.S. children and youth aged 1 month to 17 years, it was also observed higher rates of physical abuse in boys (4.5%), than in girls (2.9%) [3].

It has been suggested that ACEs are common across all the population groups, nonetheless due to economic and social conditions some individuals are more susceptible to be exposed to these experiences, and the risk of adverse health outcomes increases as the number of ACEs increases [7].

### 1.2. ACEs and health outcomes

Early adverse experiences and their impact in health outcomes later in life are becoming a topic of increasing interest. The association between exposure to ACEs and the increased risk of adverse effects across lifespan has increasingly becoming a recognized public health concern, with long-term outcomes ranging from poor academic performance to early death [8-10] (Figure 1). Individuals who experience adversity during childhood may be more susceptible to disease development through both changes in physiological development and adoption of health-risk behaviours [11]. As a consequence, childhood adversity seems to reflect in poor mental and physical health outcomes in adulthood [12, 13].

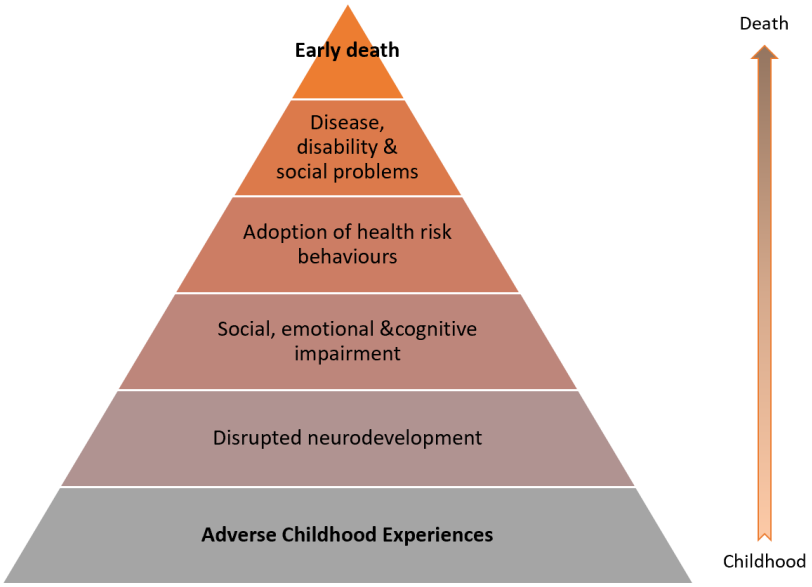


**Figure 1.** Mechanism by which adverse childhood experiences influence health and well-being throughout the lifespan (Adapted from: Centers for Disease Control and Prevention) [14]

In 2017, a systematic review and meta-analysis investigated the associations of experiencing multiple ACEs with several lifestyle behaviours and health conditions which are major causes of the global burden of disease [10]. Exposure to ACEs was identified to affect all 23 of the health outcomes examined. Individuals reporting at least four ACEs were substantially more likely to engage in health-damaging behaviours, or have chronic disease, than those with none [10]. Associations were weak or modest for physical inactivity, overweight or obesity, and diabetes, moderate for smoking, heavy alcohol use, poor self-rated health, cancer, heart disease, and respiratory disease, strong for sexual risk taking, mental ill health, and problematic alcohol use, and strongest for problematic drug use and interpersonal and self-directed violence [10].

In the relationship between ACEs exposure and health outcomes, several authors have described a cumulative risk hypothesis, characterised by a dose-response relationship where an increased number of ACEs leads to increased problems with behavioural, physical, and mental health throughout the life course

[8, 15]. Since individuals who have experienced one ACE have an increased likelihood of experiencing another, the prospect of adverse cognitive and health-behaviour outcomes also increases [8].

Although the health effects of ACEs in adults have been explored in the last decades, only more recently research started to investigate the short-term impacts of these events. During childhood, relationship between the number of ACEs and increased risk of health and developmental difficulties have also been described. In a recent systematic review, childhood adversity was associated with delays in cognitive development, asthma, infection, somatic complaints, and sleep disruption, prior to the age of 20 years [16]. Another study with a nationally representative sample of young American children (under 6 years of age) found a strong positive relationship between the number of ACEs experienced and the count of special health care needs (e.g. taking prescription medication, requiring more medical services, needing special therapies) [17].

The high burden and long-term consequences that childhood adversity entail demonstrate the need to invest in preventive and therapeutic strategies from early childhood.

### 1.3. Pathophysiological mechanisms linking ACEs to adverse health outcomes

In the last years, research has tried to identify the mechanisms through which exposure to adverse experiences is associated with adverse health outcomes. Two main pathways have been proposed to explain the relationship: an indirect one, by the adoption of unhealthy behaviours (e.g., poor diet, sedentary behaviour, smoking), which are likely to be acquired by individuals from contexts of greater social adversity, or a direct one, through physiological changes that

results from the chronic stress exposure [18]. In this theoretical framework, the experience of acute or chronic stressors during sensitive periods of childhood development which can induce several known biological responses, are likely to have an impact on subsequent biological and behavioural functions depending on the timing of initial exposures [18].

In this context, stressors would likely to be appraised as threatening, producing a psychological state that is experienced as stress, and the cascade of behavioural and biological adjustments are commonly described as responses [19]. As brain development is affected by stress and hormone levels become distressed (which are known to affect diet, exercise, and sleep), early childhood is a critical developmental stage to deal with prolonged stress and represents a high risk period for physiologic disturbances that affect both physical and mental health [20]. Changes in intellectual processes, such as concentration, memory, language, and organizational skills, may also occur and impact essential functions for children in school [8]. Later in life, these disturbances are also expressed in maladaptive behaviours such as depression, anxiety, aggression, and substance abuse [21].

Research has suggested that stressful experiences during child development can alter other maturational processes. The disfunction of the hypothalamus–pituitary–adrenal axis is another extensively studied mechanism through which psychosocial stress in childhood acts [22]. The hypothalamus–pituitary–adrenal axis is also a modulator of inflammatory processes and might contribute to the development of inflammatory diseases in adulthood [23]. Thus, changes in the nervous, endocrine, and immune systems of children have been described as the

main pathophysiological pathways to explain ACEs long-term effects in adulthood [11].

### 1.4. ACEs and diet-related outcomes

Available evidence supports that individuals exposed to ACEs have an increased risk of several unhealthy behaviours, and many diet-related conditions such as obesity, binge-eating disorder, bulimia nervosa, anorexia nervosa, irritable bowel syndrome and inflammatory bowel disease [24-29]. For instance, in a cross-sectional analysis of a nationally representative sample of U.S. young adults, those experiencing multi-type childhood maltreatment, were more likely to report binge eating-related concerns and fasting/skipping meals [30]. In addition, several other problematic eating and food-related behaviours (e.g., emotional eating, compulsive eating, overeating, stealing or hoarding food) have been referred to play a key role in the relationship between adverse childhood experiences and obesity [31]. The eating behaviours adopted in childhood seem to be highly affected by the stress and emotion dysregulation resulting from the adverse experiences, and this can explain changes in food consumption observed among children exposed to ACEs.

This relationship has been investigated, but mostly in studies with adults [32-36] and dietary intake assessment was restricted to a small number of food groups [33, 35, 37, 38]. The majority of the studies suggest that adults reporting more ACEs have a significantly lower consumption of fruit and vegetables [33-35], and when the overall diet quality was assessed, through the Healthy Eating Index, ACEs were associated with a poor diet in adulthood, especially for those reporting household disfunctions [32].

In children, although fewer studies have focused on total diet, they suggest a worse diet quality already in childhood for those exposed to ACEs [37, 39, 40]. In this context, childhood adversity has emerged as a strong predictor of obesogenic food consumption, with most of the studies assessing consumption of salty snacks, sweets, sugar-sweetened beverages and fast-food, observing a generally higher consumption in children reporting more ACEs [38-40]. Among 5 years old U.S. children, those exposed to psychological and physical maltreatment presented a higher consumption of several processed food groups, and similar results were obtained in this sample when maternal and paternal incarceration was investigated [40]. Other studies focused their analysis on healthy food groups and concluded that children with more adverse experiences were less likely to consume fruit and vegetables [37, 41]. These associations are still poorly understood but can be, at least in part, explained by the changes in the household environment. In a study with children 6 to 17 years of age, those with no ACEs were more likely to share four or more family meals per week than children with one or more ACEs [25]. Family plays an important role by creating a social environment where children learn and adopt eating behaviours. In the context of food consumption, parents share norms, knowledge, attitudes and behaviours to children, through their own practices and parenting style. These will influence children's food cognitions and ultimately their food choices [42, 43].

### 1.5. Dietary patterns definition

The assessment of the relationship of diet with the risk of disease or other health outcome is challenging and complex [44]. Traditionally, nutritional epidemiology relied on a single food group or nutrient to examine the association

with chronic diseases [45]. In the last decades, dietary patterns have been established has as an alternative, but complementary approach, which allows to characterise dietary behaviour in a broader way, where foods and nutrients are eaten in combination. Dietary patterns allow to capture the complexity of dietary intake, accounting for the potential interactions between nutrients in whole diets [45, 46].

Three main approaches can be distinguished to identify dietary patterns: the hypothesis-driven approaches (or *a priori*), the exploratory approaches (or *a posteriori*) and hybrid approaches [46-48]. The hypothesis-driven approach is based on previous knowledge about the relationship between certain dietary factors and health and/or major diet-related-diseases [46]. In this method, researchers define scores or indices, which are usually based on guidelines for a healthy diet [47]. The scores can be used not only to reflect total diet quality, such as the Healthy Eating Index [49], but also to classify the adherence to a dietary approach for disease prevention or treatment, such as the Dietary Approaches to Stop Hypertension (DASH) diet [50], or the adherence to specific ways of eating, such as the Mediterranean diet [51].

In contrast, the exploratory approaches do not rely in *a priori* hypotheses since dietary patterns are derived through statistical modelling using collected dietary data [45]. Statistical methods, such as principal component analysis and cluster analysis are the most commonly applied to derive dietary patterns from the available data [47]. These exploratory approaches aggregate data from a larger set of dietary variables and reduced to form a smaller set of variables, identifying the dietary patterns. According to Hu [45], an hypothesis-driven approach can be

more advantageous when relevant dietary components for the disease have been clearly identified.

Finally, the hybrid approaches compromise between hypothesis-driven methods and data-driven methods. This approach combines prior knowledge about variables potentially relevant in the biological pathways of a disease with underlying dietary intake data [47, 52]. The reduced rank regression (RRR) has been the more widely used statistical method. RRR allows to choose disease-specific variables and determine combinations of food intake that explain as much response variation as possible [53].

Overall, dietary patterns are recognised as an effective way to assess diet intake and examine the combined effect of foods and related components, taking into account their synergetic effects [54]. Dietary patterns may also capture the cumulative effects of multiple nutrients, which may be too small to be detected when one single diet component is assessed [45]. They can characterise dietary behaviour in a more comprehensive and real-life approach, considering the potential interaction of nutrients in the whole diet, which generally is not reflected in the single food group or nutrient approaches [46].

### 1.6. Gaps in the literature between ACEs and Diet

Available evidence on the associations between ACEs exposure and diet poses some limitations which restrains the understanding of this relationship. The majority of the studies relied on cross-sectional analyses of samples with adult participants who retrospectively self-reported adverse experiences under the age of 18 years. This approach raises problems of memory bias, due to the time gap between the experiences and the report, which could be prevented by assessing

occurrence of ACEs still during childhood. In this regard, prospective cohort studies can be valuable since they allow the follow-up participants since early age, closer to the timing of exposure, until the onset of outcomes to be studied.

Another gap in the literature concerns the methodology used to assess diet, since most research focused on particular food groups, such as fruit and vegetables or, in some cases, on dietary patterns established *a priori*. This methodology allows to measure total diet quality, but it does not allow a comprehensive view of the natural aggregation of food consumption choices.

## 2. Objective

This study has the main objective of investigate the association between ACEs (by dimensions and number of adverse events across childhood) and the dietary patterns identified at 10 years old, in children from the prospective birth cohort Generation XXI.

To answer to the objective of this dissertation, a manuscript was produced, which is presented in the results' section of this dissertation.

## 3. Results

**Manuscript: Association of adverse childhood experiences with dietary patterns of school-age children: evidence from the birth cohort Generation XXI**

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**Keywords**: Feeding behaviour; Diet; Adversity; Cohort Studies; Childhood

**Abstract**

**Background**: Adverse Childhood Experiences (ACEs) have been associated with high-risk health behaviours and several chronic diseases in adulthood. However, the relationship between the exposure to ACEs across childhood and dietary patterns at school-age is unknown.

**Objective**: To investigate the association between ACEs (by dimensions and number of adverse events across childhood) and dietary patterns of 10-year-olds.

**Methods**: Participants are children from the Generation XXI cohort, recruited at birth between 2005 and 2006 in Porto, Portugal. There were included 5034 children evaluated at birth and at the 10-year-old follow-up. ACEs exposure was assessed through a self-administered questionnaire and grouped into 5 dimensions by principal component analysis: "abuse", "school problems", "death/severe disease", "life changes", and "household dysfunction". Dietary patterns were identified by latent class analysis using data collected with a validated food frequency questionnaire. Five dietary patterns were studied: "low consumption", "energy-dense foods", "snacking", "intermediate consumption", and "healthier" (used as reference). Multinomial regression analyses were conducted to evaluate the associations, and *odds ratio* and the respective 95% confidence intervals were presented (OR, 95%CI) (co-variates: household income, family structure and mother's age), with child's sex stratification.

**Results**: Most children were exposed to at least one ACE (96%), and the prevalence was higher in boys for all dimensions of ACEs except "life changes". Girls reporting "abuse" and "death/severe disease", were more likely to follow less healthy dietary patterns ("low consumption": OR=1.44, 95%CI = 1.12-1.85 and OR=1.62,

95%CI = 1.18-2.23; and “energy-dense foods”: OR=1.37, 95%CI = 1.07-1.71 and OR=1.41, 95%CI = 1.04-1.92), respectively) at age 10, compared with those with no ACEs on these dimensions and following the “healthier” pattern. In boys, only the total sum of ACEs was associated with dietary patterns; those reporting ≥ 6 ACEs were more likely to follow the “low consumption” (OR=1.97, 95%CI = 1.00-3.87) and “energy-dense foods” (OR=3.83, 95%CI = 1.27-11.55) dietary patterns than children not reporting ACEs (“healthier” dietary pattern as reference).

**Conclusions:** Exposure to ACEs was associated with less healthy dietary patterns in school-aged children, and differences between sexes were observed. Results suggest that specific dimensions of ACEs, such as abuse and a traumatic event, play an important role in the association with dietary patterns in girls, while in boys the total number of experiences seemed to be the most important factor.

## INTRODUCTION

Adverse Childhood Experiences (ACEs) can be described as stressful and traumatic experiences that have occurred in the first 18 years of life, such as violence, abuse or neglect, and represent an increased risk for the later development of adverse behavioural and health outcomes [1, 2]. In particular, individuals experiencing adversity during childhood show a greater risk of cardiovascular diseases, obesity, type 2 diabetes, and cancer [3-5]. Early adversity can lead to changes in brain architecture and chronic inflammation as a reaction to the chronic stress exposure, supporting important mechanism pathways to explain these associations [6]. However, the effects of ACEs on health are not only explained by biological mechanisms, but also by psychosocial, and behavioural factors [7, 8]. In previous studies, ACEs exposure was linked to high-risk health behaviours, and in particular to changes in adult eating behaviours, namely the onset of binge eating disorders, which might result from the high levels of stress and anxiety [9, 10]. The behavioural changes seem to develop still in childhood, since the prevalence of emotional overeating and eating in the absence of hunger is higher among children under ACEs [11]. ACEs have also been associated with higher consumption of energy-dense foods (e.g. fast-food, salty snacks, sugar-sweetened beverages, sweets) [12, 13] and a lower consumption of fruit and vegetables [2, 14]. Children experiencing these events, also show higher rates of overweight, particularly in longitudinal studies, which suggests a cumulative effect of adverse experiences over the lifespan [15].

The existing evidence on this topic is mostly from cross-sectional studies with adults, which may be a limitation considering that adults tend to underreport experiences of child abuse when reporting the experiences at adult age [16]. In

addition, studies exploring the relationship between ACEs and diet were mainly focused in certain food groups, such as fruit and vegetables [14]. To our knowledge, no studies have explored the effect of childhood adversity on food consumption using a broader approach as dietary patterns, which can gather the interaction and cumulative effects of several foods and nutrients and be more representative of the actual food choices [17, 18]. Therefore, our main objective was to investigate the association between ACEs, reported at 10 years old in relation to previous life events, and their dietary patterns at that age, using data from a large birth cohort.

## METHODS

### Study design and participants

The study sample included children enrolled in the prospective population-based birth cohort Generation XXI, described in detail elsewhere [19, 20]. A total of 8647 newborns and their mothers were recruited, between April 2005 and August 2006, at all the public maternities in the Porto Metropolitan Area (Northern Portugal), which represented 95% of the deliveries in the whole catchment population. All families from baseline were invited to participate in the follow-up evaluations when children were 4, 7 and 10 years old, achieving 86%, 80%, and 74% participation proportion, respectively.

In this study, data are from the 10-years-old follow-up which took place between July 2015 and July 2017, and enrolled 6397 children. Children with congenital anomalies or diseases that might influence dietary intake (e.g. celiac disease, food allergy, food intolerance and phenylketonuria) were excluded from the sample (n=43), as well as second born twins (n=114), participants with missing information on ACEs data (n=987), diet information and other variables of interest

used as co-variates (n=219). In the case of multiple births, only the first born was considered in the analysis. After exclusions, our final sample size included 5034 children (Figure 1). When comparing the characteristics of the current study participants with the remaining cohort (n=3613), mothers of those included in our sample were slightly older [mean=29.9 years; standard deviation (SD)=5.2 vs mean=27.9; SD=6.6] and more educated [mean=11.3 years; SD=4.3 vs mean=9.6; SD=3.9]. However, the magnitude of the differences was not high, according to the Cohen`s effect size (Cohen`s d = 0.34 for maternal age and 0.40 for maternal education) [21], thus the observed significant differences may be due to the large sample size and not due to systematic differences between participants.

**Data collection**

In Generation XXI, socioeconomic indicators have been extensively evaluated since birth and across childhood [22]. At the 10-years-old follow-up, information on the history of disease, dietary habits and other health-related behaviours were collected by trained professionals through face-to-face interviews, or retrieved from parental self-completed questionnaires.

**Adverse Childhood Experiences across childhood**

To assess the exposure to ACEs from birth until 10 years of age, a self-administered questionnaire was applied to participants consisting of 15 items coming from the original ACE study [1], combined with items from the Child and Adolescent Survey of Experiences: Child Version (CASE) proposed by Allen et al, in 2012 [23]. The instrument includes measures of abuse, household dysfunction, stressful events, and problems at school. All items were dichotomised, and children were asked to answer whether or not the event had ever occurred. A

familiar and safe environment was provided, and children answered the questionnaire privately in the presence of a trained interviewer to ensure assistance in case they needed it. The measure of childhood adversity was obtained by summing all possible events, such as the scores could range from 0 to 15. These measures have also been described in previous papers [24, 25]. For statistical analysis, the total number of ACEs was later categorised into 0 ACEs, 1–3 ACEs, 4–5 ACEs, and ≥ 6 ACEs.

A principal component analysis (PCA) was used to determine which ACE items were closely correlated and reduce the size of the dataset. By grouping correlated items, five ACE dimensions were created: “abuse”, “school problems”, “death/severe disease”, “life changes”, and “household dysfunction”. Each of the dimensions includes all children reporting at least one of the ACE items included in that specific dimension. The complete methodology was described elsewhere [26].

**Dietary Patterns at 10 years-old**

Dietary intake was assessed at the 10-years-old follow up wave through a qualitative Food Frequency Questionnaire (FFQ), applied to the children’s main caregiver by trained interviewers. This instrument is composed by 41 food items and uses a nine-point scale ranging from “≥4 times per day” to “less than once a month or never” to describe the habitual dietary consumption in the previous six months. The mean daily consumption (in grams per day) was estimated by a z-score method using the frequency reported in the FFQ and the mean and standard deviation (SD) of food consumption reported in three-day food diaries (two weekdays and one weekend day), as previously described [27].

Using data from the FFQ, and considering the categorical nature of the response items and their asymmetric distribution, dietary patterns were identified by latent class analysis (LCA) [28]. This methodology was used in previous studies in this cohort when analysing dietary patterns at 4 and 7 years of age [29, 30]. LCA aggregates children into homogeneous classes (dietary patterns) based on the highest probability of class membership and probabilities of choosing each item response (e.g. consumption categories) [31]. To perform this analysis, selected food items from the FFQ were converted into quintiles of food consumption (in grams per day). Bayesian information criterion [32] was used to determine the number of classes, being five obtained as the most appropriate solution (four DPs: BIC=167346.9; five DPs: BIC=167314.9, six DPs: BIC=167360.2).

In the next step, children were assigned to one of the classes (dietary pattern) based on the probability of selecting each food item category. Class 1 had a higher proportion of children in the fifth quintile (higher consumption) 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 it was named as "healthier". Class 2 presented a higher proportion of children with lower consumption of various food groups, such as yoghurts, cheese, eggs, seafood, bread, vegetables, fruit, butter and coffee/tea, being named as "low consumption". Class 3 was composed of children with higher consumption of crisps, pizza/burger, salty pastry, cookies, candies and soft drinks, and lower consumption of vegetable soup and seafood, being named as "energy-dense foods". Class 4 showed a higher proportion of children in the fifth quintile of consumption of milk, yoghurt cheese, processed meat, bread, butter and

coffee/tea. This dietary pattern was labelled as “snacking”, since these foods or food groups are usually consumed between main meals. Finally, the last class was characterised by an intermediate consumption of several food groups, namely of milk, yoghurts, cheese, eggs, processed meat, fruit, butter, cookies, candies and soft drinks, therefore named as “intermediate consumption”. More information could be found in a previous paper from our research group [28].

**Covariates**

Extensive data covering socioeconomic conditions, lifestyles, and measured anthropometry were also collected for both mother and child by trained professionals. Based on previous literature and exploratory statistics, some of these variables were included as potential confounders of associations, as described next. Sex at birth was dichotomised into girls and boys. Household monthly income was classified into three categories: ≤1000€/month vs. 1001–2000€/month vs. >2000€/month, and family structure into two categories: living with both parents vs. living in lone parenthood or with others (when children is living only with the mother, only with the father, or with other family members). Mother’s age, in complete years, was included as a continuous variable.

Other variables were used to describe the study sample, such as child’s weight status at age 10, which was converted into age and sex-specific BMI z-scores and categorised according to the World Health Organization growth reference [33], and sports practice used to describe children with regular and scheduled practice of sports out of school.

**Ethics**

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures approved by the Ethical Committee of São João Hospital/University of Porto Medical School (27 April 2005) as well as by the Portuguese Data Protection Authority (Protocol code 5833, approved on 30 May 2011). Written informed consent was signed by parents (or legal guardian) of each participant after an explanation about the purposes and design of the study and oral assent was obtained from children.

**Statistical analyses**

Participant's characteristics were described as counts (n) and percentages (%) for categorical variables. For continuous variables, median and interquartile range (IQR) or mean and standard deviation (SD) were used, depending on normality of the distribution. Counts and proportions of ACEs in the study sample were compared by child's sex using the Chi-square test.

Multinomial regression models were performed to study the association between ACEs (used as exposure) and the five dietary patterns identified at 10 years of age (outcome). The "healthier" dietary pattern was the reference category in all analysis. Initially, the exposure to ACEs was defined as the sum of ACEs of the participants classified into four categories (0 ACEs, 1–3 ACEs, 4–5 ACEs, and ≥ 6 ACEs). On a second step, the previously established dimensions of ACEs were used to assess a different variable of exposure ("abuse", "school problems", "death/severe disease", "life changes", and "household dysfunction"). Different models were compared considering potential confounding variables, being the final model adjusted for household income, family structure and mother's age. A

sex-modification effect was found in the associations under study as results changed according to sex stratification and thus analyses are presented separately for girls and boys. The results are presented as Odds Ratios (OR) and their respective 95% confidence intervals (95 % CI).

Data were analysed using the statistical package IBM® SPSS® Statistics 2017 for Windows, Version 25.0. and a p-value of $< 0.05$ was established for statistical significance.

## RESULTS

Characteristics of the participants (n=5034) are summarised in **Table 1**. At baseline, mothers of the children included in the study had a mean age of 29.9 years (SD=5.2), a median of 12 years of education (IQR=8) and a pre-pregnancy BMI of 22.9 kg/m$^2$ (IQR=4.7). Approximately 49% of the children in the sample were girls, and 42.2% presented overweight or obesity at 10 years of age. At that age, the majority were living with both parents (78.5%) and with siblings (63.7%), were in public schools (89.6%) and had a regular sports practice (63.3%).

From the dietary patterns identified at 10 years of age, 20.6% of the children in the study followed the "healthier" pattern, 25.1% followed the "low consumption" pattern, 11.5% followed the "energy-dense foods" pattern, 13.2% followed the "Snacking" pattern, and 29.5% followed the "intermediate consumption" pattern (**Table 1**).

In this sample, the prevalence of children who have been exposed to at least one ACEs was 96%, and approximately 27% had reported 6 or more ACEs throughout life, significantly higher in boys than in girls (31.6% vs. 21.1%, $p<0.001$) (**Table 2**). The most frequent experiences reported were a household member shouting,

yelling, or screaming at the child (57.9%), witnessing parents arguing or fighting (44.4%), the death of a family member or close friend (43.4%), moving from a house, school, or neighbourhood (42.6%) and being beaten and hurt at school (42.6%). The prevalence was significantly higher in boys for most of these experiences. When assessing ACEs according to the five dimensions identified, "abuse" had the highest prevalence, with 71.6% of the children reporting to have experienced at least one of the situations described, significantly higher in boys for all the experiences. In general, a significantly higher prevalence of ACEs was observed in boys in all dimensions except for "life changes".

Multinomial regression models explored the associations between ACEs and the dietary patterns, separately by child's sex (**Tables 3a and 3b**). In girls, no associations were observed between the total sum of ACEs reported and the dietary pattern followed at 10 years of age. When analysing by dimensions of ACEs, girls reporting "abuse" and "death/severe disease", compared with those with no ACEs of these dimensions, showed increased odds of following the "low consumption" (OR=1.44, 95%CI = 1.12-1.85 and OR=1.62, 95%CI = 1.18-2.23, respectively), and the "energy-dense foods" dietary patterns (OR=1.37, 95%CI = 1.07-1.71 and OR=1.41, 95%CI = 1.04-1.92) than following the "healthier" dietary pattern. For those reporting "death/severe disease" experienced during childhood, a 50% higher odds of following the "snacking" dietary pattern (OR=1.48, 95%CI = 1.09-1.99) was also observed. Girls reporting "life changes" ACEs were less likely to follow the "low consumption" (OR=0.73, 95%CI = 0.56-0.95) and the "intermediate consumption" dietary patterns (OR=0.77, 95%CI = 0.60-0.98), while those with "household dysfunction" were more likely to follow the "energy-dense foods" dietary pattern (OR=1.46, 95%CI = 1.04-2.05), when

compared with children who did not report ACEs of these dimensions and using the Healthier dietary pattern as reference category (**Table 3a**).

In this analysis performed with boys, children with a higher sum of ACEs (≥ 6 ACEs), compared with no ACEs, were at 2-fold increased odds to follow the "low consumption" and at 4-fold increased odds to follow the "energy-dense foods" dietary pattern (OR=1.97, 95%CI = 1.00-3.87 and OR=3.83, 95%CI = 1.27-11.55, respectively) than following the "healthier" dietary pattern. Increased odds of following the "intermediate consumption" were observed for those reporting 4-5 ACEs (OR=1.92, 95%CI = 1.01-3.64). No significant associations were found for the different ACEs dimensions among boys.

## DISCUSSION

In this study, exposure to ACEs was associated with less healthy dietary patterns in school-aged children, and a sex-modification effect was found. In girls, specific dimensions of ACEs, such as abuse and a traumatic event, were associated with less healthy dietary patterns, while in boys only the total number of experiences, at least 6 ACEs, yielded significant associations with the "low consumption" and "energy-dense foods" dietary patterns.

These findings build on previous studies in adults which observed a lower diet quality in individuals exposed to adverse events during childhood [34, 35]. A cross-sectional analysis assessed the prevalence of ACEs and the Healthy Eating Index-2010 (HEI-10) scores of more than 30.000 adults from the U.S. The authors concluded that having experienced ACEs of any category was associated with worse HEI-10 scores, regardless of the sex of the participant, and the odds of worse HEI-10 were higher with the increasing number of ACEs [34]. The ACEs count

also showed to have a strong relationship with several health harm behaviours in a nationally representative survey of English adults, where it was estimated to predict 13.6% of having a poor diet [35]. Nevertheless, the impact of each particular dimension of adverse experience was not investigated.

A decreased consumption of fruit and vegetables can partly justify the poor diet quality described in these studies. Results among young adults showed that ACEs were linked with a set of unhealthy outcomes, including higher BMI, alcohol abuse, lower hours of sleep, and also a lower consumption of fruit and vegetables [2]. Studies in older individuals, such as college students and adults, have shown that participants reporting more ACEs and those who had experienced parental divorce/separation had an increased risk of low fruit and vegetable consumption [2, 14], generally accepted as a marker of low quality diets.

Our results suggest that the association between adverse experiences and poor dietary habits may develop still in childhood. Although few studies have assessed these associations in young populations, a study conducted in a large sample of children from the U.S. aged 10 to 11 years old arrived at similar conclusions [36]. The authors classified the level of exposure to ACEs into three categories and investigated the association with diet, sleep, and physical activity, after one year follow-up. Children in the high exposure group had significantly worse diet, compared with those not reporting any ACE, and the results suggested a dose-response relationship. Their diet was assessed by a diet quality score, according to which the increased consumption of fast foods and sweets, and lower consumption of vegetables, as isolated food groups, was highlighted [36]. Another study prospectively assessed the effects of ACEs (reported by mothers) in the toddlers' diet at 2 and 4 years of age, and observed a negative association

between ACEs and the frequency of fruit intake, independently of the socioeconomic status (SES) [37].

Research has shown that children from low SES families are more prone to be exposed ACEs than others, exacerbating health inequities [38, 39]. In previous studies, low SES have also been associated with greater central adiposity [40], and to an increased risk of overweight and obesity [41]. Nevertheless, ACEs are prevalent across all demographic characteristics. Results from the present study were adjusted for the household income, and as described by other authors [34, 37], associations with unhealthier food choices were still observed, indicating an involvement of multiple mechanisms. One of the proposed models refers to the biological changes that occur as result of the toxic stress generated by the ACEs, explaining the worst health outcomes in adulthood. This toxic stress causes a pro-inflammatory tendency in cells and affects hormonal responses [42]. Most importantly, these early stressors seem to increase the tendency of people to develop poor self-regulation skills and to engage in high-risk behaviours [42, 43], including poorer quality diets.

Changes in food consumption among individuals reporting adverse experiences seem to be accompanied with several negative emotional and behavioural outcomes, which may explain the adoption of unhealthy eating behaviours [44]. The early life stress resulting from the ACEs exposure is the proposed mechanism to establish a link with some eating disorder symptoms [9]. In this context, several studies have reported an association between childhood adversity and binge-eating disorders, not only in adults [45-47], but also in early adolescents [48]. While in others, an increased risk of anorexia nervosa and bulimia nervosa was reported among adolescents [49]. The poor diet quality that results

from these behaviours increases the risk of a number of chronic health conditions [6], but the underlying mechanisms explaining these associations are complex and involve not only behavioural, but also psychological and physiological aspects [51]. Further investigation is needed to better understand the interaction between these factors.

In accordance with our findings for boys, the current evidence supports the hypothesis of a cumulative effect of ACEs, and some studies report a dose-response relationship with unhealthy eating behaviours. Nevertheless, the literature does not allow to clearly conclude on the most important categories. ACEs under the dimension of "abuse" and "life changes", such as domestic violence and parental divorce, were those with stronger evidence of influencing child's dietary intake. In a previously described study in children, domestic violence was associated with a less frequent consumption of fruits and a more frequent consumption of sweet snacks and sugar-sweetened beverages [37]. Children experiencing parental divorce or those with a family member in prison showed a worse diet quality, with lower consumption of fruit and vegetables as adults [14, 34]. To the best of our knowledge, sex differences described in our study were not observed or analysed by other researchers, which hampers any further considerations.

Strengths and limitations of the methodology used should be considered to the interpretation of results. The major strength of the current study is relying on a self-administered questionnaire to assess exposure to ACEs, instead of using information provided by the main caregiver. In addition, the report was done with a short lag time, minimizing at least some memory bias which is a major constraint of previous research conducted in adult populations. Moreover, to study overall

diet, we used a wider approach as dietary patterns, according to which it was possible to incorporate multiple food groups, instead of focusing on isolated food groups. Other strength of the project is the extensive, high-quality data collected within a large prospective birth cohort (Generation XXI), allowing the application of robust methodological approaches and a prospective design that spans birth through childhood. Losses of follow-up are expected to occur in prospective birth cohorts, and although we have included a sample with more than 5000 children, after stratifications by sex, dietary patterns and classes of ACEs, some of the associations are less precise (with wider confidence intervals), due to the reduced sample size in some of the categories under comparison.

In addition, since this research relies in a cross-sectional analysis, exposure and outcome were both measured at 10 years of age, and temporal relationships cannot be assured, although ACEs were asked to be reported across childhood (before age 10). ACEs exposure was based on the original CDC's ACE study that assesses a score based on a list of personal and family-related types of childhood trauma. In this study, we also use ACE dimensions based on a previously conducted principal component analysis, and the number of dimensions was chosen based on the screen plot, the size of the factor loadings, and interpretability of the resulting dimensions. Although Cronbach alpha coefficients were low for the majority of dimensions, these 5 dimensions may most accurately reflect the types of ACEs, and each dimension is distinguishable by the item of ACEs loading on it. Limitations may also include the parental report of children's diet. This methodology might lead to an over report of healthy foods driven by social desirability. Nevertheless, previous data have been compared with 3-day food records and showed a moderate agreement [27]. Also, the labelling of dietary

patterns might be controversial, as we labelled the reference dietary pattern as "healthier" mainly based on the inclusion of evidence-based healthier food groups, such as fruit and vegetables, and a lower consumption of ultra processed foods, but future studies should disentangle its effects on health outcomes.

## CONCLUSIONS

In conclusion, this study suggests that an association between exposure to ACEs and less healthy dietary patterns occurs early in life, supporting the existing evidence linking adverse experiences in childhood with health-risk behaviours. Differences between sexes were observed, showing that girls were more susceptible to deviate from a healthy dietary pattern when exposed to "abuse" or "death/severe disease" of a close one, while in boys a cumulative effect between the number ACEs and a diet high in energy-dense foods and with low food consumption was observed, independently of family income.

A better understanding of the underlying mechanisms explaining the increased likelihood of children exposed to ACEs following less healthy dietary patterns, is still needed. Furthermore, future research should explore how these experiences affect boys and girls differently and investigate if these findings in other childhood populations, are replicable. In several epidemiological studies, the negative behavioural and health impacts associated with ACEs highlight the need to develop effective prevention policies and public health interventions targeting, in particular, the most vulnerable population groups. These findings highlight the need of prevention and intervention actions that can reduce exposure to ACEs and its consequences, namely in diet.

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**Figure 1.** Study Flowchart of participants

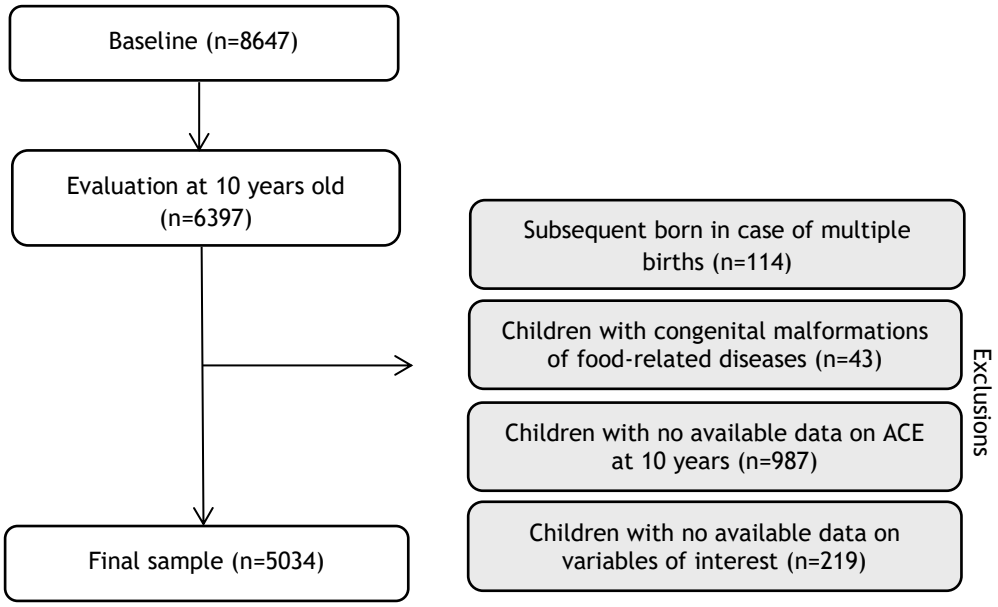

**Table 1.** Mother and child characteristics at baseline and 10 years old follow-up (n=5034)

| *Mother characteristics* | n (%), M (SD) or Md (IQR) | |
|---|---|---|
| **Age (years) at baseline, M (SD)** | 29.9 (5.2) | |
| **Education (years) at baseline, Md (IQR)** | 12.0 (8.0) | |
| **Pre-pregnancy BMI (kg/m$^2$), Md (IQR)** | 22.9 (4.7) | |
| **Weight gain during pregnancy (kg), Md (IQR)** | 13.0 (7.0) | |
| **Smoking during pregnancy, n (%)** | | |
| No | 3999 (79.4) | |
| Yes | 1035 (20.6) | |
| **Marital status at baseline** | | |
| Married/in a relationship | 4789 (95.3) | |
| Single/separated/divorced/widowed | 234 (4.7) | |
| **Household monthly income at 10y (€)** | | |
| ≤1000 | 1300 (25.8) | |
| 1001-2000 | 2335 (46.4) | |
| >2000 | 1399 (27.8) | |
| *Child characteristics at 10 years of age* | Girls 2471 (49.1) | Boys 2563 (50.9) |
| **BMI z-score, Md (IQR)** | 0.7 (1.8) | 0.7 (1.9) |
| **Weight status, n (%)** [a] | | |
| Underweight (< -2 SD) | 24 (1.0) | 30 (1.2) |
| Normal weight (−2 ≤ SD ≤ 1) | 1417 (57.3) | 1436 (56.0) |
| Overweight (1 < SD ≤ 2) | 671 (27.2) | 624 (24.3) |
| Obesity (> 2 SD) | 359 (14.5) | 473 (18.5) |
| **Family structure, n (%)** | | |
| living with both parents | 1946 (78.8) | 2007 (78.3) |
| living in lone parenthood or with others | 525 (21.2) | 556 (21.7) |
| **Living with siblings, n (%)** | | |
| No | 896 (36.3) | 931 (36.3) |
| Yes | 1575 (63.7) | 1632 (63.7) |
| **School type, n (%)** | | |
| Public | 2220 (89.8) | 2288 (89.3) |
| Private | 228 (9.2) | 248 (9.7) |
| Other | 23 (1.0) | 26 (1.1) |
| **Sports practice, n (%)** | | |
| No | 1027 (41.6) | 818 (31.9) |
| Yes | 1444 (58.4) | 1744 (68.0) |
| *Dietary Patterns* [b] *at 10 years of age* | n (%) | n (%) |
| Healthier | 530 (21.4) | 507 (19.8) |
| Low consumption | 598 (24.2) | 668 (26.1) |
| Energy-dense foods | 283 (11.5) | 297 (11.6) |
| Snacking | 287 (11.6) | 378 (14.7) |
| Intermediate consumption | 773 (31.3) | 713 (27.8) |

M: Mean; Md: Median; SD: Standard deviation; IQR: Interquartile range; BMI: Body mass index; y: years; [a] BMI z-scores defined according to the WHO Growth Charts (World Health Organization, 2006).
[b] Dietary patterns defined by latent class analysis in a previous study (28).

**Table 2.** Prevalence of Adverse Childhood Experiences (ACEs) at 10 years of age according to the child's sex (n=5034)

| | *Prevalence, n (%)* | | | | |
|---|---|---|---|---|---|
| | All (n = 5034) | Girls (n = 2471) | Boys (n = 2563) | *p-value* [a] | *Dimension of ACEs* |
| **1.** Have you ever witnessed your parents arguing or fighting? | 2233 (44.4) | 989 (40.0) | 1244 (48.5) | <0.001 | Abuse |
| **2.** Did someone in the household shout, yelled or screamed at you? | 2917 (57.9) | 1294 (52.4) | 1623 (63.3) | <0.001 | |
| **3.** Did someone in the household swears at, insult, put you down, or humiliate you? | 473 (9.4) | 177 (7.2) | 296 (11.5) | <0.001 | |
| **4.** Did someone in the household hit, kick or punch you? | 918 (18.2) | 394 (15.9) | 524 (20.4) | <0.001 | |
| **5.** Have you ever had difficulties at school? | 1994 (39.6) | 965 (39.1) | 1029 (40.1) | 0.427 | School Problems |
| **6.** Someone in your school ever beat and hurt you? | 2147 (42.6) | 868 (35.1) | 1279 (49.9) | <0.001 | |
| **7.** Were your parents ever called to the school because you did something wrong? | 637 (12.7) | 150 (6.1) | 487 (18.9) | <0.001 | |
| **8.** Did someone you were very close to (family or friend) die? | 2187 (43.4) | 1070 (43.3) | 1117 (43.6) | 0.842 | Death/Severe Disease |
| **9.** Did someone in the household have an injury or severe illness? | 1751 (34.8) | 826 (33.4) | 925 (36.1) | 0.047 | |
| **10.** Did you have an illness or accident that forced you to stay or go to the hospital many times? | 645 (12.8) | 253 (10.2) | 392 (15.3) | <0.001 | |
| **11.** Did your parents ever separate or divorced? | 1028 (20.4) | 495 (20.0) | 533 (20.8) | 0.502 | Life changes |
| **12.** Did you ever move from a house, school or neighbourhood? | 2145 (42.6) | 1043 (42.2) | 1102 (43.0) | 0.572 | |
| **13.** Have you ever heard your parents talking about the household financial hardships? | 1121 (22.3) | 542 (21.9) | 579 (22.6) | 0.576 | Household Dysfunction |
| **14.** Did someone in the household is a problem drinker or use street drugs? | 77 (1.5) | 24 (1.0) | 53 (2.1) | 0.002 | |
| **15.** Did a household member ever go to prison? | 175 (3.5) | 92 (3.7) | 83 (3.2) | 0.348 | |
| ***Sum of Adverse Childhood Experiences, n (%)*** | | | | | |
| 0 ACEs | 199 (4.0) | 126 (5.1) | 73 (2.8) | <0.001 | |
| 1-3 ACEs | 2052 (40.8) | 1127 (45.6) | 925 (36.1) | | |
| 4-5 ACEs | 1451 (28.8) | 697 (28.2) | 754 (29.4) | | |
| ≥ 6 ACEs | 1332 (26.5) | 521 (21.1) | 811 (31.6) | | |
| ***Participants with at least one ACE of the dimension, n (%)*** | | | | | |
| Abuse | 3602 (71.6) | 1660 (67.2) | 1942 (75.8) | <0.001 | |
| School Problems | 3172 (63.0) | 1399 (56.6) | 1773 (69.2) | <0.001 | |
| Death/Severe Disease | 3196 (63.5) | 1535 (62.1) | 1661 (64.8) | 0.048 | |
| Life changes | 2555 (50.8) | 1231 (49.8) | 1324 (51.7) | 0.192 | |
| Household Dysfunction | 1277 (25.4) | 619 (25.1) | 658 (25.7) | 0.612 | |

ACEs: Adverse Childhood experiences; [a] ACEs were compared between girls and boys with the Chi-squared test.

**Table 3a**. Multinomial logistic regression for associations between Adverse Childhood experiences (ACEs), as a total sum and by dimensions, and dietary patterns at 10 years of age **in girls** (n=2471).

| | **Dietary Patterns** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Healthier | | Low consumption | | Energy-dense foods | | Snacking | | Intermediate consumption | |
| | n (%) | | n (%) | OR (95% CI)* | n (%) | OR (95% CI)* | n (%) | OR (95% CI)* | n (%) | OR (95% CI) * |
| **Total sum of ACEs** | | | | | | | | | | |
| 0 ACEs | 28 (5.3) | 1.00 (reference) | 34 (5.7) | 1.00 (reference) | 8 (2.8) | 1.00 (reference) | 15 (5.2) | 1.00 (reference) | 41 (5.3) | 1.00 (reference) |
| 1-3 ACEs | 271 (51.1) | 1.00 (reference) | 263 (44.0) | 0.80 (0.46-1.36) | 109 (38.5) | 1.36 (0.60-3.11) | 130 (45.3) | 0.89 (0.46-1.72) | 354 (45.8) | 0.88 (0.53-1.47) |
| 4-5 ACEs | 138 (26.0) | 1.00 (reference) | 157 (26.3) | 0.90 (0.51-1.59) | 97 (34.3) | 2.23 (0.96-5.16) | 90 (31.4) | 1.17 (0.59-2.34) | 215 (27.8) | 1.02 (0.60-1.75) |
| ≥ 6 ACEs | 93 (17.5) | 1.00 (reference) | 144 (24.1) | 1.12 (0.62-2.00) | 69 (24.4) | 2.10 (0.89-4.98) | 52 (18.1) | 0.93 (0.45-1.93) | 163 (21.1) | 1.10 (0.63-1.91) |
| **ACEs dimensions**[1] | | | | | | | | | | |
| Abuse | 334 (25.5) | 1.00 (reference) | 419 (26.5) | **1.44 (1.12-1.85)** | 205 (25.2) | **1.62 (1.18-2.23)** | 188 (25.2) | 1.14 (0.84-1.54) | 514 (25,7) | 1.19 (0.94-1.51) |
| School Problems | 285 (21.8) | 1.00 (reference) | 331 (20.9) | 0.93 (0.73-1.18) | 176 (21.7) | 1.20 (0.89-1.63) | 167 (22.4) | 1.10 (0.82-1.47) | 440 (22.0) | 1.05 (0.84-1.32) |
| Death/Severe Disease | 301 (23.0) | 1.00 (reference) | 386 (24.4) | **1.37 (1.07-1.75)** | 185 (22.8) | **1.41 (1.04-1.92)** | 190 (25.5) | **1.48 (1.09-1.99)** | 473 (23.7) | 1.20 (0.96-1.50) |
| Life changes | 278 (21.3) | 1.00 (reference) | 282 (17.8) | **0.73 (0.56-0.95)** | 160 (19.7) | 1.00 (0.72-1.38) | 137 (18.4) | 0.75 (0.55-1.04) | 374 (18.7) | **0.77 (0.60-0.98)** |
| Household Dysfunction | 110 (8.4) | 1.00 (reference) | 163 (10.3) | 1.25 (0.94-1.66) | 86 (10.6) | **1.46 (1.04-2.05)** | 63 (8.5) | 0.98 (0.68-1.39) | 197 (9.9) | 1.24 (0.95-1.63) |

ACEs: Adverse Childhood experiences; OR: Odds Ratio; 95% CI: 95% Confidence Interval. Significant associations ($p<0.01$) are highlighted in bold type. Reference category is the Healthier dietary pattern (n=533)

*Model adjusted for household income, family structure and mother's age.

[1] Reference category: Not having any ACE of the dimension.

**Table 3b.** Multinomial logistic regression for associations between Adverse Childhood experiences (ACEs), as a total sum and by dimensions, and dietary patterns at 10 years of age **in boys** (n=2563).

| | **Dietary Patterns** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Healthier | | Low consumption | | Energy-dense foods | | Snacking | | Intermediate consumption | |
| | n (%) | | n (%) | OR (95% CI)* | n (%) | OR (95% CI)* | n (%) | OR (95% CI)* | n (%) | OR (95% CI)* |
| **Total sum of ACEs** | | | | | | | | | | |
| 0 ACEs | 23 (4.5) | 1.00 (reference) | 16 (2.5) | 1.00 (reference) | 5 (1.3) | 1.00 (reference) | 9 (2.4) | 1.00 (reference) | 20 (2.8) | 1.00 (reference) |
| 1-3 ACEs | 197 (38.9) | 1.00 (reference) | 234 (35.0) | 1.64 (0.85-3.19) | 99 (33.3) | 2.90 (0.97-8.69) | 141 (37.3) | 1.92 (0.85-4.30) | 254 (35.6) | 1.53 (0.81-2.88) |
| 4-5 ACEs | 141 (27.8) | 1.00 (reference) | 193 (28.9) | 1.82 (0.93-3.57) | 80 (26.9) | 3.00 (0.99-9.08) | 110 (29.1) | 2.02 (0.89-4.58) | 230 (32.3) | **1.92 (1.01-3.64)** |
| ≥ 6 ACEs | 146 (28.8) | 1.00 (reference) | 224 (33.5) | **1.97 (1.00-3.87)** | 114 (38.4) | **3.83 (1.27-11.55)** | 118 (31.2) | 2.02 (0.89-4.60) | 209 (29.3) | 1.66 (0.87-3.17) |
| **ACEs dimensions**[1] | | | | | | | | | | |
| Abuse | 380 (27.4) | 1.00 (reference) | 513 (26.2) | 1.12 (0.85-1.47) | 226 (25.5) | 1.03 (0.74-1.45) | 278 (25.6) | 0.94 (0.69-1.28) | 545 (26.8) | 1.10 (0.84-1.44) |
| School Problems | 328 (23.6) | 1.00 (reference) | 474 (24.1) | 1.21 (0.94-1.56) | 215 (24.3) | 1.27 (0.92-1.74) | 266 (24.5) | 1.18 (0.88-1.58) | 490 (24.1) | 1.14 (0.89-1.45) |
| Death/Severe Disease | 317 (22.8) | 1.00 (reference) | 422 (21.5) | 1.03 (0.81-1.32) | 195 (22.0) | 1.13 (0.84-1.53) | 245 (22.5) | 1.12 (0.84-1.48) | 482 (23.7) | 1.26 (0.99-1.61) |
| Life changes | 251 (18.0) | 1.00 (reference) | 362 (18.5) | 1.15 (0.89-1.49) | 160 (18.1) | 0.96 (0.69-1.33) | 192 (17.7) | 1.00 (0.74-1.35) | 359 (17.6) | 1.02 (0.79-1.32) |
| Household Dysfunction | 114 (8.2) | 1.00 (reference) | 190 (9.7) | 1.23 (0.94-1.62) | 89 (10.1) | 1.27 (0.91-1.77) | 106 (9.7) | 1.22 (0.89-1.66) | 159 (7.8) | 0.94 (0.71-1.24) |

ACEs: Adverse Childhood experiences; OR: Odds Ratio; 95% CI: 95% Confidence Interval. Significant associations ($p<0.01$) are highlighted in bold type. Reference category is the Healthier dietary pattern (n=1038)

*Model adjusted for household income, family structure and mother's age.

[1] Reference category: Not having any ACE of the dimension.

## 4. Discussion and Conclusions

To our knowledge, the present study was the first to investigate the effects of early adversity on children's food consumption by deriving dietary patterns emerged from the aggregation of food choices. The results give new perspectives that emphasize specific needs of research in this field, which are crucial to implement preventive measures and develop adequate public health policies, particularly among the most vulnerable.

A high prevalence of ACEs (96%) was observed at 10 years of age in a sample of over 5000 children form the birth cohort Generation XXI, and associations with less healthy dietary patterns were found. The percentage of participants reporting ACEs is considerably higher than in other studies in adults, highlighting the relevance of assessing adversity still in childhood [(2)]. By assessing boys and girls separately, we concluded that specific dimensions of ACEs, such as "abuse" and a "death/severe disease" of a close one, were associated with less healthy dietary patterns in girls, while in boys a cumulative effect was observed when at least six ACEs were reported. In both cases, children experiencing more adverse events tend to follow dietary patterns characterised by a higher intake of crisps, pizza/burger, salty pastry, cookies, candies and soft drinks, or with an overall lower consumption of various food groups.

Research indicates that certain psychosocial factors, such as stress resultant from early adversity, can disrupt normal eating behaviours both through direct biological and indirect behavioural changes [(55)]. The proposed underlying mechanism explaining the relationship between ACEs and dietary habits suggests that toxic stress originates hormonal dysregulations and behavioural adjustments which lead to decreased intake of healthy foods [(56)].

Although several studies have identified differences in the prevalence and categories of ACEs most reported by boys and girls, it is still unclear how sex modifies the association between ACEs and food consumption. In our study, ACEs under the dimension of “abuse” and “school problems” were significantly more prevalent in boys. Other types of ACEs, which in the literature are mostly associated with girls [4, 57], such as sexual abuse, were not assessed in our study. Previous research has reported the same cumulative effect of ACEs observed in the boy’s sub-sample, nonetheless the number of experiences that must occur before a change in diet or other health-related behaviour begins is not possible to determine. Sex differences need further investigation to allow a better understanding of the impact of ACEs in different individuals and adapt public health policies and interventions if required.

Another key point of the study is the age at which ACEs and diet were assessed. Our results support the short-term impact of these stressful experiences on children's behaviour. A growing body of evidence has shown that the health-related consequences of childhood adversity can be observed at a young age [58]. However, more evidence on how ACEs affect diet in young populations is needed, and the reproduction of the current analysis in other samples, in particular in children from other age groups, could help clarifying the onset time of the observed associations.

Potential limitations of this study should be addressed for the interpretations of the results. The questionnaire used to retrospectively assess the prevalence of ACEs is a reliable and valid method, however the number of items covered is limited and other authors have adapted the scale to screen for additional adversity, such as trauma associated with war, forced displacement and others to

cover sexual abuse [59, 60]. However, the questionnaire used in this study attempted to cover the most common experiences at these ages. Additionally, the questionnaire relies on a simplistic scoring approach, and it does not assess the timing or the frequency of adversity. Therefore, it is not possible to investigate if repeated exposure to events of lower intensity could be more strongly related to adverse outcomes than an isolated event considered highly intense [59]. On the other hand, it would be difficult for children to specify the timing of such experiences, but we do believe they are able to report the most significant experiences. Also, because school-aged children were responsible for answering the questionnaire, potential under-reporting of ACEs should not be excluded, given the lack of maturity and understanding of the participants to assess certain life experiences. For the same reason, and considering the sensitive nature of the question, sexual abuse was not included in this assessment by decision of the cohort's coordination team, although it is one of the most traumatic events. Lastly, it should be considered that food consumption was reported by the main caregiver, which can potentially lead to an over report of healthy food intake due to social desirability, but the FFQ was previously tested in children from Generation XXI and showed good psychometric properties.

A major strength of this study is the large sample of 10-year-old children participating in the population-based birth-cohort, the Generation XXI, used to assess the association between ACEs and dietary patterns. As the questionnaire was self-completed in a trustworthy environment and close to the time of these experiences, a higher accuracy in the report of adversity is expected, compared to the assessment in adulthood. Another strength of our methodology is the double approach used in the analysis of ACEs: by total sum of events and by dimension,

which allowed a broader interpretation of the relationship with diet. Regarding the outcome variable, the use of dietary patterns was a way to address one of the major limitations of the existing evidence, and giving a wider view of children's food consumption instead of relying on isolated food groups.

The results and associations found in this study highlight the need of prevention and intervention actions that can reduce exposure to ACEs and its consequences. The vast majority of the children in the Generation XXI cohort reported at least one ACE, with a particular high prevalence of abuse experiences. Considering the body of evidence linking childhood adversity with several health-risk behaviours and long-term health effects, a public health concern is risen. Appropriate strategies to prevent this outcome are nevertheless complex and require the involvement of social and health-care professionals. In this context, food and nutrition education can play and important role when integrated in a well-planned intervention program. Efforts should focus first on preventing adverse experiences, and when is no longer possible, efficient intervention measures should take place in order to mitigate the health consequences.

It is my view that the complexity of adversity in childhood emphasize the need of a multidisciplinary approach, in which the identification and close monitoring of children at risk of developing harmful health-related behaviours are key to reduce the long-term impacts. Hence, the implementation of healthy food school environments along with adequate nutrition policies targeting young populations may be essential preventing less healthy dietary patterns.

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