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REVIEW ARTICLE

Transgenerational transmission of eating habits

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KEYWORDS
Eating habits;
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Abstract
Objective: To investigate the relationship between the biopsychosocial environment and eating habits and behaviors that lead to the selection and consumption of certain food from the earliest stages of life. To clarify whether there is an interaction between genetic and epigenetic factors, and how they shape eating habits.
Data source: A narrative review based on research in PubMed and Web of Science electronic databases was carried out over the last 10 years, searching the title and summary fields using the keywords Children OR adolescents Feeding Behavior eating OR Dietary Habits OR Eating Behavior OR Eating Habits OR Children obesity.
Data synthesis: The generational transmission of eating habits is related to the home, community, and school environments, mainly during the first years of life, and can exert the modulation of habits during all stages of life. During childhood, the family's role in consolidating eating habits is very broad and ranges from choosing foods to prioritizing family meals, including the lifestyle.
Conclusions: Eating habits are transmitted from parents to children in different ways: environmental, emotional, social, and educational. In cases of obesity, a greater association of genetic influence can be observed.
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Introduction

Eating habits can be defined as "the result of more or less conscious, collective and repeated behavior, which lead individuals to select, prepare, consume and use certain foods or diets in response to social, cultural and religious influences".[1] Children's long-term development and health are associated with eating habits from the beginning of life.[2] Bad eating habits are risk factors for being overweight in childhood and adolescence and for chronic diseases in adulthood. They are frequently related to the intake of foods rich in calories and lipids, food selectivity, eating quickly or eating in inappropriate environments.[2,3]

Eating habits are shaped in childhood by a combination of genetic and environmental factors and can accompany the individual during adolescence and adulthood, as well as the consequences of their food choices.[4-7] Through the same factors, eating habits can be transmitted through the generations, influencing dietary patterns and nutritional status

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from the early stages of life. After childhood and adolescence, food preferences continue to change according to age and are decisive for food choices and, therefore, for the quality of eating habits.[7]

Around the world, children learn eating habits by eating with their parents, grandparents, caregivers, siblings, and friends. Therefore, the home environment, the community, and the school are crucial settings for nutritional education that help in decisions about what, how much, when, and how children eat from the moment they are born, and throughout childhood and adolescence.[8] It is a complex and dynamic process that is influenced by socio-emotional, environmental, cultural, and political factors. The incidence of these factors at the individual, family, community, or population level over time determines the transgenerational transmission of eating habits, which results in the perpetuation of dietary patterns at different moments in human history. Advances in food technology have led to greater availability of high-energy and low-nutrient food products, while globalization and urbanization have resulted in changes in lifestyle as a whole, from the home environment to child dietary self-regulation, to the availability of the physical presence of parents to feed their children.[8]

The knowledge of mechanisms underlying eating habits can be useful to pediatricians and professionals involved in child health, as it encourages healthy eating behaviors in the pediatric population from the earliest stages. These attitudes related to healthy eating behavior should be the basis for nutritional guidelines, nutritional education programs,[8] and public policies focused on controlling the increasing prevalence of childhood obesity and its comorbidities.

Data synthesis

Genetic predisposition to food tastes and preferences

Food preferences and aversions play an important role in food choices, especially in children.[2] Despite the scarcity of studies, genetic factors seem to influence the development of food preferences, the regulation of appetite and metabolism, body fat distribution, and the presence of behaviors such as eating speed, responsiveness to satiety, and pleasure when eating.[2,9] Examples of this is the evidence that suggests that human beings' preference for sweet or salty flavors over bitter flavors, which characterized scarce and caloric foods and potentially toxic foods respectively, was inherited from primates.[10] In the past, a mix of innate preferences and the capacity to develop new preferences (i.e., learning what is nutritious and safe to eat) seemed to be crucial to survival.[2] Furthermore, studies carried out with newborns have associated the aversion to bitter foods with genetic factors.[10] There is a pattern of children's food preferences observed from the very early stages of eating, which suggests the existence of innate predispositions in relation to flavors.[2]

Babies' almost universal preference for sweet foods, as well as the widespread rejection of vegetables and legumes, can be modified through positive experiences and repeated exposure to foods. Children's inclination to accept new or specific foods has a strong to moderate genetic background that is shaped by cultural and environmental differences, which influence early exposure to the taste and texture of foods.[2] Therefore, eating behaviors and practices have the power to modify the interaction between genetic predisposition and the environment in the shaping of food preferences.

The influence of the environment on eating habits

Eating behavior and food preferences tend to accompany the child during the transitions from the intrauterine environment to breastfeeding and from breastfeeding to the introduction of complementary foods.[6,10] The predilection for certain flavors and foods can be shaped and modified in early periods of pre-and post-natal life due to the high sensitivity of the central nervous system of the fetus and the newborn to environmental factors and the characteristic plasticity of these stages of life.[10]

Evidence suggests that, before birth, fetal exposure to flavors through the amniotic fluid predisposes to positive responses to these stimuli in postnatal life; although little studied and understood, the baby's preference for the salty taste seems to be related to the severity of emesis gravidarum.[10]

In postnatal life, especially in the first years of life, child feeding is the protagonist of the relationship between parents and children and occupies a large part of the physical and social environment of the home. On the other hand, parents and the home environment play key roles in the child's feeding, nutrition, and development of eating habits,[5,11] choosing what is offered to them and providing examples of good eating habits.[5,12] Generally, the likelihood that a certain food will be offered is associated with the parents' tastes and preferences.[7]

The domestic environment is considered one of the most important settings when it comes to the transmission of eating habits between generations. The physical characteristics of the domestic environment include the accessibility and availability of different foodstuffs, while family meals are the sociocultural representation of this environment, interspersed with affections, expectations, and emotions. For this reason, nutritional guidelines for children and their families during childhood must encompass not only food and nutrients but, above all, the food environment.[5] The influence of the home environment on the development of healthy eating behaviors in childhood and adolescence has been demonstrated in previous studies, but the mechanisms underlying this influence have not yet been clarified. Aspects such as the availability and accessibility of a certain food in the child's home are examples of factors in the home environment that are associated with the consumption of and preference for that food, be it an ultra-processed product sweets [sweetened drinks, cookies and snacks] or fresh food.[11,13] Studies have shown that fruit and vegetable intake by young individuals was positively associated with the availability of healthy foods at home and negatively associated with the availability of less healthy foods.[8] Often, lack of time, lack of family resources [financial and emotional], and the cost of healthy foods are barriers to providing healthy foods at home. A Brazilian study showed that children who attended preschool for 8—10 h a day had higher energy intake with poorer nutritional quality if they ate at home

rather than in the preschool environment.[14] In addition to being a key setting for providing food to children, the home environment also provides powerful food cues for children and adolescents. The way the family talks about foods, body weight, and body image can influence children's eating behavior. There should be a family effort to reduce children's access to television, in part due to the association between television and sedentary behavior, but also due to the broadcast of food advertisements, which provide cues for eating in the absence of hunger and promote the consumption of less healthy types of food.[8]

To investigate the role of the home environment in the transmission of eating habits between parents and children, a multicenter study carried out with European families concluded that the shared home environment influenced food intake among biological relatives, such as parents and siblings, and among non-biological ones, such as spouses.[15] Several studies conducted on the African continent showed that children who were orphaned [of one or two parents] or were separated from their parents for health reasons had greater dietary diversity compared to children who lived with their parents or were not orphans,[16-18] with the consumption of fruits, legumes, and vegetables more than three times a week versus consuming unhealthy foods (bakery products, sweetened drinks, and restaurant food) a maximum of three times a week.[17] The results suggest that the child's interaction with other individuals, regardless of the biological relationship, changes eating habits through factors related to the environment. Finally, the impact of the emotional environment at home on the quality of family nutrition stands out, which is directly associated with the formation of children's eating habits. High levels of parental stress, caused by financial difficulties, difficulty balancing work and family responsibilities, lack of time, gender inequality, discrimination of all types, and depression, have been associated with less frequent and less healthy family meals.[8]

The power of models of eating habits

The development of children's eating habits is complex and strongly influenced by the parents' eating behavior, which, in turn, is shaped by the parents' emotional and cultural beliefs and relationships with food. These are constructed throughout the parents' trajectory with their diet, which in turn, was influenced by the eating behavior of their parents. The perceptions shared within a family about a healthy lifestyle build a positive family system that can be inherited from parent generations, constituting a transgenerational link. This system involves the beliefs, attitudes, and cognitions of family members and participates in the process that establishes and promotes beneficial health behaviors through role modeling and encouraging the adoption of healthy eating behaviors.[7]

The transmission of eating behaviors from parents to their children occurs continuously when the child eats with their parents. Although the definitions vary between studies, "eating together" or "eating as a family" is generally defined as "a child who eats a planned meal with at least one parent or adult family member/caregiver."[8] Studies suggest that the frequency of eating together has declined in recent years largely due to parental time constraints.[8]

Having frequent family meals seems to be related to healthy eating behaviors and greater consumption of healthy foods, in addition to offering benefits for the child's physical and mental health.[5,7,8,13,19] Adolescents who ate five to seven meals per week with their families showed increased self-efficacy for healthy eating, both at home with their family and at social events with friends, had fewer depressive symptoms, skipped fewer meals, and had less concern about their body weight.[20]

However, a Brazilian cohort study published in 2018 indicated that the quality of the environment was more important than the frequency of shared meals.[12] This study also showed that parents with positive attitudes during meals provided more routine and consistency to children, ensuring a stable and supportive environment, which was related to a lower consumption of sweetened beverages and lower frequency of oppositional behavior.[12] Similarly, Coelho and Pires (2018) demonstrated that children who perceived a more supportive family environment felt more comfortable expressing their feelings and had greater control over their food intake and healthier eating patterns.[21]

The frequency and context of family meals have the potential to improve dietary intake among children of all ages. Moreover, evidence suggests that the benefits of eating with one's family extend into adulthood.[8] A North American study that monitored adolescents aged 16 to 20 years demonstrated that there is a strong constancy in the trajectory of eating behaviors from adolescence to adulthood and that the greater frequency of meals with the family and eating breakfast are associated with a higher frequency of consumption of fruits, vegetables, and whole grains consistently throughout this period.[22] The mechanisms through which frequent sharing of family meals can promote healthy eating habits are: 1) The foods consumed during family meals are healthier than those consumed during meals without the family or outside the home; 2) Eating together as a family allows parents an opportunity to model healthy food intake and eating patterns; 3) Eating together provides a context in which children can implicitly learn about healthy eating through mealtime conversations and the emotional tone of the meal.[8] Studies in the field of childhood obesity have established the association between high BMI in parents and high BMI in children, which can be attributed to genetic factors and, above all, to the environment shared between parents and children, including eating habits and lifestyle.[23] Increasing evidence that the influences of the father's and mother's BMI on childhood obesity are similar reinforces the predominance of the shared environment effect.

Despite the evidence in favor of frequent sharing of family meals, in recent decades family organization has had impacts on the domestic environment, such as increased use of technology, changes in traditional practices, lifestyle, parental involvement, food availability and, consequently, on eating habits.[8] It is important to know what parents recognize as motivating aspects or obstacles to having frequent family meals. Parents of young children identify social connection and practical considerations as reasons for eating with their children, while poor planning and the possibility of disorganized meals are mentioned as reasons for not eating with one's children. Parents of school-age children and adolescents also identify social connection as a motivation to eat together, as well as an opportunity to model healthy

behaviors for their children. The main obstacles to family meals among parents of older children include time constraints, not having enough energy to cook the meals, limited financial resources, and challenges managing the food preferences of multiple family members.[8] Another factor that has been interfering with the quality of family meals is the indiscriminate use of screens such as cell phones, tablets, television, and computers, which constantly compete for a place at the table that was previously reserved for conversations. The use of screens and television during meals is associated with offering less healthy foods and reducing the intake of healthy foods, practices that can be decisive in the formation of eating habits.[8]

The role of frequent, quality family meals in the transgenerational transmission of healthy eating habits is one of the main examples of how the parents' behavior at meal times is relevant in this process. Eating practices are individual, goal-oriented behaviors that parents use to encourage their children to do, or not do, something specific, such as eating their vegetables and not eating cookies or sweets.[8] To shape their children's food preferences, parents use different behaviors that are a mix of effective and ineffective strategies.[7] Eating practices are influenced by parenting styles, described according to the emotional atmosphere that parents create with their children during meals, which, in turn, influences eating behaviors.[8] Parenting styles originate from the combination of the degree of demand that parents place on their children's nutrition and the parent's ability to respond to their children's demands. Parenting styles reflect the parents' beliefs and attitudes and manifest themselves through the ways and rules that parents choose to determine what, how much, when, and how their children eat.[8,24,25]

Studies suggest that positive eating practices are associated with better results in terms of eating habits and healthy eating in children and adolescents than more negative practices. Positive practices are considered to be structured ones (environments that encourage children's competence, for instance, regular meal times, ensuring that healthy foods are accessible, and parents as role models for their children) and those that support autonomy (based on encouragement and praising, which provide enough support to nurture the child's ability to regulate their eating without being too strict). Furthermore, getting the children involved in meal preparation, serving children the same foods that their parents eat, and promoting a positive environment at mealtime are practices that have a positive influence on children's eating habits.[8]

On the other hand, coercive and controlling practices are considered negative ones, which may be associated with unhealthy eating habits and behaviors, especially in older children and adolescents.[8] In general, coercive strategies are counterproductive, have a detrimental effect on nutrition, and should be avoided. It is important to mention the premise that parents exhibit different eating behaviors to feed their children depending on the situation, and it is common for them to adopt different degrees of control and permissiveness depending on the environment.[8] Parental behaviors such as offering and encouraging the consumption of healthy foods and demonstrating healthy eating habits can favor the development of healthy eating habits in children.[4,5,26] In the obesogenic environment, it was also observed that moderate restriction strategies, characterized by moderate levels of parental control and gradual reduction, rather than prohibition of unhealthy foods, are probably necessary to moderate the intake of these foods, may be beneficial and result in lower caloric intake, less consumption of fatty and sweet treats, and greater consumption of fruits.[5,7,26]

The influence of parenting styles on food socialization

Pleasure plays an essential role in controlling the act of eating and shaping food choices, which are driven by the pursuit of pleasure and reinforced by the pleasure experienced in consuming food.[8] This is even particularly decisive in children because other determinants of food choices are less present due to children's immature cognitive abilities. Considering that eating is often a social situation, one of the dimensions of pleasure in eating is interpersonal, which is experienced in the context of food consumption. Social eating encourages interactions between people during meals and is crucial for developing eating habits.

In some cultures, children are exposed to strong flavors at an early age. For example, in Mexico, they are given spicy foods. Learning to like initially unpleasant foods may be part of a food socialization process.[7] Individual patterns of food preferences and eating behaviors emerge and differ depending on the psychosocial and cultural contexts of eating during critical stages, such as complementary feeding.

"Food socialization" is the process by which parents help their children adopt healthy eating practices, values, beliefs, and behaviors that are practiced and accepted by both their immediate family and the culture surrounding them.[8] Parents are the first and main influences in the initial stages of an individual's food socialization. Babies and preschoolers depend entirely on their parents' guidance about appropriate eating practices and preferences. As they grow and develop, children and adolescents enjoy greater independence, a variety of eating environments, eating companions, and food choices. Although the parental environment remains of the utmost importance throughout childhood and adolescence, food socialization needs change, parental control decreases, and peer influences become dominant. In adolescence, parents expect their children to have adopted family traditions and values that are used to guide food choices and eating behaviors, as they become independent and autonomous adults.[8]

Food socialization strategies can be classified according to the way in which parents shape the eating habits their children will carry as legacies for their future. Between the 1970s and 1980s, in the United States, Baumrind, Maccoby, and Martin developed psychological constructs used in studies on parental influence and children's outcomes.[7,27] Since then, four parental prototypes have been defined, reflecting four feeding styles, or parenting styles: 1) Authoritative or responsive; 2) Authoritarian; 3) Indulgent; 4) Neglectful or uninvolved.[7,8,25,27] While authoritative parents make healthy foods available and may gently encourage eating, authoritarian parents may provide healthy foods but expect children to eat what is set out in front of them and force them to eat. Responsive parents monitor their child's behavior and convey clear patterns without resorting to intrusive or restrictive approaches.[7] Parents with permissive profiles [indulgent and uninvolved] have few expectations regarding

their children's eating behaviors; indulgent parents only provide food that they know their children will eat, are more tolerant, and avoid conflicts, while uninvolved parents have a low degree of control and response, provide food that is convenient for them at that time, without taking into account the nutritional values or their children's preferences.[8] In general, children of authoritative parents have the best outcomes in terms of healthy eating and self-regulation.[7,8,25] Two systematic reviews concluded that children who lived in homes with responsive characteristics tended to have healthier diets and nutritional status; however, the associations tend to be indirect and weak.[28,29]

The DNA of the childhood obesity epidemic

Obesity has genetic causes and can be classified as monogenic, polygenic, and syndromic, such as Prader-Willi and Bardet-Biel syndromes. In the presence of genetic predisposition, multiple environmental factors contribute to the disorganization of energy homeostasis regulation circuits, leading to obesity.

Monogenic mutations involving a single gene or chromosomal deletions that cause large effects are rare, and when present, they lead to an early onset of obesity.[23] These mutations occur mainly in regions of the DNA that encode proteins of the leptin-melanocortin pathway, responsible for energy homeostasis through the regulation of food intake and energy expenditure. Alterations in different affected genes have variable penetrance and expression and result in a variety of manifestations and symptoms of obesity, such as hyperphagia, severe early-onset obesity, hormonal disorders such as hyperinsulinism and hypothyroidism, accelerated linear growth, hypertension, energy homeostasis impairment, and gastrointestinal disorders.[9,23]

On the other hand, polygenic obesity is the most common cause of obesity in children and to which the obesity epidemic is attributed. It results from the interaction of a complex genetic history consisting of the combination of effects of genetic variants common in the general population, in combination with the environment or independently. Twenty-five gene loci have been associated with BMI in children. Single nucleotide polymorphisms (SNPs) are the most common types of genetic variation among people and can contribute, each with a small part, to the development of the obesity phenotype by interacting with epigenetic modifications. Among genetic variants related to obesity, those located in the fat mass and obesity-associated gene (FTO) locus were the first to show a strong association with BMI. The FTO gene, expressed in the hypothalamus, is located on chromosome 16 and encodes an enzyme implicated in the control of energy homeostasis, food intake, and energy expenditure.[9] Genetic variants that are more often present in children with obesity than in children without obesity seem to be related to increased production, secretion, and circulating levels of pro-inflammatory molecules, including tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), which have been associated with hypertriglyceridemia, liver inflammation, and adipose tissue inflammation.[9]

The field of studies in the epigenetics of childhood obesity is new and growing rapidly. Most of the results support the hypothesis that DNA methylation changes are predominantly consequences of obesity.[23] Future research should attempt to verify whether DNA methylation patterns in specific regions in the prenatal period can be regulated by genetic variation/(SNPs) in genes also correlated with childhood obesity, thus confirming the possibility of a passive and active role of DNA methylation in regulatory interactions that influence gene expression.[9]

Increasing evidence discusses the possibility of transgenerational inheritance of environmental exposures to generations of descendants never exposed to parental stimulation, which highlights the role of exposure to obesogenic factors and excess weight before and during pregnancy in the transgenerational epigenetic programming that explains the hereditary nature of obesity and its comorbidities in children.[9] According to these findings, paternal pre-pregnancy exposure and/or exposure during pregnancy contribute both to maternal weight gain and obesogenic factors. Excess weight, nutrient deficiency, excessive weight gain, and exposure to obesogenic environments during pregnancy subject the sperm, ovum, and placenta to inflammation, oxidative stress, lipid accumulation, and insulin resistance, in addition to altering the epigenetics of breast milk and altering the mother' energy and glucose metabolism.[9,30]

Conclusions

Strategies for transmitting healthy eating habits to future generations

Based on the literature review carried out to prepare this article, the transgenerational transmission of eating habits is mediated by the interaction of genetic and environmental factors. In this process, the home environment and parents' eating behaviors are key elements and are subject to social, cultural, and political influences. Knowledge of the underlying mechanisms allows pediatricians not only to prevent excess weight and associated comorbidities in childhood and adulthood but also to protect future generations from the impacts of obesogenic environments.

In summary, the strategies that can contribute to the transgenerational transmission of healthy eating habits are listed below:

- Disseminate the need for health planning in the pre-pregnancy phase. The quality of eating habits during the preconception period positively influences the health of the future baby.
- Offer nutritional support to pregnant women, raising awareness of the adoption of a healthy lifestyle.
- Encourage the parents to establish healthy habits early in the child's life.
- Use structured eating practices that support the child's autonomy.
- Avoid coercive, restrictive and prohibitive practices.
- Adopt a responsive eating style, which promotes the child's eating self-regulation and is associated with healthy eating habits.
- Avoid indulgent, controlling or permissive eating styles.
- Promote a positive emotional and physical home environment.
- Be an example of good eating habits at home.

- Share family meals frequently, giving importance to the quality of interaction during meal times.
- Avoid using screens during family meals.
- Control exposure to unhealthy food advertising.
- At home, encourage healthy food choices by ensuring nutritious foods are available, affordable and attractive.
- Allow the child to participate in pleasant meals so that they can witness other people eating healthy foods.
- Avoid reinforcing the pleasure of eating unhealthy foods (for example, offering them as a reward).

Conflicts of interest

Mauro Fisberg: Occasionally works as a speaker for Abbott Nutrition, Nestlé Nutrition Institute, Danone Nutricia and Reckitt Benckiser.

Nathalia Gioia: Nothing to declare.

Priscila Maximino: Occasionally carries out scientific technical consultancy work for the food and food ingredients industry.

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