



OPEN Nutrition knowledge of primary schoolchildren in Poland from the parents' perspective based on qualitative studies

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Unhealthy nutrition among schoolchildren causes different diseases during childhood and later life, and the nutrition habits created in this period will continue in the future life. The aim of this study was to estimate schoolchildren's food and nutrition knowledge based on parents' opinions collected during qualitative research conducted using the Focus Group Interview (FGI) technique among 49 parents of primary school pupils from the capital city of Poland-Warsaw. Based on these findings, it was concluded that nutrition education for school children is needed because of the current lack of appropriate knowledge in both children and their parents, especially in practical aspects. Nutrition education is necessary to change pupils' attitudes toward food and nutrition, especially their nutritional behavior and responsible food choices. For this purpose, traditional and modern IT and telecommunications tools can be used; however, it should be noted that they must be used under adult supervision to understand better the different aspects of proper nutrition and food choices and to distinguish advertising from nutrition knowledge. The results provide a theoretical basis for undertaking intervention measures based on the family and school. It is important to underline that nutrition education at home, the equal institution in terms of importance within formulating proper attitudes toward food and nutrition as well other kinds of social behavior as school, can be realized during everyday activities connected with meal preparations.

Keywords Nutrition knowledge, Food and nutrition, Primary schoolchildren, Parents' opinions, Focus group interview

The statement that childhood is an important stage for the formation of human habits is widely known and confirmed by many scientists worldwide. Many of them suggest that childhood is an important stage for forming consumer habits^{1,2}. It should also be underlined that many chronic diseases develop over decades and have their roots in childhood^{3–6}. Prevention of diet-related diseases during childhood and early adolescence is an important public health goal because of the prevailing attitudes towards food and nutrition as well as eating habits developed during this time that significantly shape dietary patterns later in life^{7–10}. It is worth mentioning that changes in food consumption patterns during the past decades have had a major impact on the increase in chronic non-communicable diseases^{11–14}.

Several factors have been identified in the literature as possible causes of diet-related diseases in children. These factors include reduced physical activity, increased screen time, snacking, and food advertising, all of which have poorly reflected on dietary recommendations and food choices^{3,15–19} raising concerns about their impact on children.

As scientists have indicated, food marketing effects on children can be cognitive (nutrition knowledge), attitudinal (liking of advertisements), and behavioral (food preferences or consumption)²⁰. Children and

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adolescents will be independent consumers in the future. Still, in childhood, they are influenced by their parents' consumer behavior, peers, teachers, and older children, who have significant spending power thanks to their pocket money^{7–10}.

Children start learning about food and nutrition from their parents^{6,21}), but during growth, the dynamics of socialization become more complex. In addition to parents, schools, and teachers, peers, as well as television and food marketing, are beginning to influence their food choices^{8,10,16,21}. The importance of peer groups reflects the need to identify with significant others, which may occur through the purchase and use of specific products or brands.

Advertising, including television advertising, plays an important role in food choice. The literature review results showed an increase in the incidence of being overweight and obese after exposure to food advertising²². Obesity and non-communicable diseases such as diabetes and cardiovascular diseases in children are influenced not only by food marketing but also by insufficient physical activity and undesirable eating habits of the child's family²³.

Children do not represent independent or fully developed consumer competencies and a lot of their activities toward food and nutrition take place within their families. On the other hand, they can influence consumer behavior in households²³ and the decisions when their parents buy food. Children in families with more health-promoting eating habits have greater opportunities to learn appropriate food choices²⁴. Parents' social norms regarding fast food, friends' preferences for this type of food, and its social acceptance are related to children's consumption of less healthy food. Research has shown that more frequent parent–child communication about food and its advertising and greater parental knowledge about nutrition reduce children's unhealthy diet behavior^{23,25}. It is worth underlining that common meals at home, as well as common physical activities, also reduce unhealthy nutritional behavior²⁶. Such evidence should be widely disseminated to promote healthy lifestyles for families requiring nutritional education²⁷.

Research objectives

The aim of this research was to determine:

- (i) Nutrition knowledge of primary schoolchildren in the opinion of their parents;
- (ii) Sources of food and nutrition knowledge of pupils from the parents' perspective;
- (iii) Purposefulness and scope of nutrition education for children and their parents;
- (iv) Parents' needs regarding communication about proper nutrition education of children.

Based on FGIs, the authors of this paper try to explore the following research problems: the level of nutrition knowledge as well as nutrition awareness among schoolchildren; which kind of nutrition education is needed for children: theoretical or more practical; what sources of nutrition education play the most important role for children and how it should be implemented in reality?

Exploration of these problems will allow us to understand the contemporary food market and the possibility of influencing children to make more health-promoting choices through the nutrition education of primary school children and their parents.

Methods

Ethics approval

The project followed the ethical standards recognized by the Helsinki Declaration. The study protocol was also approved by the Ethics Committee of the Institute of Human Nutrition Sciences of the Warsaw University of Life Sciences (Resolution No. 18/2022). All participants provided informed verbal consent to participate in the study. Data obtained during the interviews were confidential and only available to the researchers.

Study design and data collection

The exploratory research was conducted among parents of schoolchildren in a qualitative approach using the Focus Group Interviews (FGI) method. The research tool was a scenario for moderating discussions in focus groups, developed in accordance with the FGI methodology^{28,29}. In this methodology, the group discussion is "focused" on a specific research topic. During the discussion, group processes take place, as a result of which the participants influence each other's statements and discuss together the topic given by the moderator. Seven FGI studies were performed. Each interview lasted between 1.5 and 2 h. Data were obtained from the Nationwide Project 'JEŻ'³⁰, collected in 2022–2023 by well-trained researchers from the university.

Forty-nine parents of children between the ages of 7 and 12 from Warsaw (the capital city of Poland) took part in the survey. The study focused on the capital city in Poland, which is mainly characterized by a relatively high level of education among its residents, with good financial status (high level of Gross National Product). The choice of one of the largest agglomerations in Poland was due to the high percentage of overweight and obese school-age children in the Mazovia region. However, in Poland, there was no statistically significant correlation observed between the number of overweight and obese children and the urbanization level^{31,32}. Moreover, children whose parents have a higher education level, better professions, and live in cities, like parents participating in FGIs, should theoretically not be overweight and obese³³. In our research, it is interesting to see if the pupils' knowledge of food and nutrition could influence consumer food choices.

The socio-demographic characteristics of the study sample are presented in Table 1. Parents were informed at the outset about the interview's purpose, the name of the project, and how the information would be used. They were also assured of the anonymity of the study.

Variable	Description
Gender	45% men; 55% women
Age	29–48 years
Nationality	100% Polish
Place of residence	Warsaw, capital city
Education	25% middle school diploma; 75% higher education
Financial Status	20% very good, 70% good, 10% good enough

Table 1. Socio-demographic characteristics of the study sample (%).

Nutrition knowledge	Examples of parents’ statements
Satisfactory/good	“Children’s knowledge is satisfactory, but unfortunately often remains at the level of theory.”
	“Knowledge is good, more. Worse in practice, but in theory, knowledge is.”
Medium	“I rate the state of knowledge as a medium; children know the basics without going into detail.”
	“Rather average. They know the need to take vitamins in the diet and understand the need to limit sugars.”
	“Average knowledge relates to the quality of meals and hygiene issues. Parents take care.”
	“Medium, the challenge is how to reach children not only with theory but also with practice.”
Low/very low	“Their knowledge is low; children do not know about healthy food because they prefer to eat sweets and in the fast food outlets, where no attention is paid to healthy eating.”
	“Very low, negligible. There are no additional nutrition-related elements, and this should be necessary.”

Table 2. Nutrition knowledge of school-age children in the opinion of their parents.

Focus groups’ protocol

Following the recommendations in the literature³⁴, a semi-structured guide was developed for the FGIs. The guide’s purpose was to encourage discussion, provide flexibility for the follow-up questions, and ensure consistency across the focus groups. Although the focus groups followed the same sequence, the flow of questions varied between the groups due to additional questions aimed at clarifying certain points.

The interviews consisted of 7 parts, including 5 substantive parts. In part one, the moderator introduced himself, stated the purpose of the research task and the purpose of conducting the group interview, and explained the principles of group interviewing. Part two, lasting 15–20 min, dealt with opinions on the current state of children’s nutrition knowledge in the field of children’s nutrition education in the opinion of parents, with a particular focus on the state of children’s knowledge and the presence in the current curricula of content relating to the principles of proper nutrition, food products, and ways of food production. The third part (15–20 min) focused on identifying sources of nutrition knowledge and the role of social media, influencers, YouTubers and bloggers, as well as schools, parents, and peers in acquiring food and nutrition knowledge.

In the fourth part (15–20 min), parents were asked about the scope and implementation of knowledge transfer, what nutrition education for children should look like, and how long it should be implemented. Questions were also asked about knowledge transfer, whether there should be a theoretical form, or whether practical classes should also be introduced. They were also asked about the need to develop a separate curriculum for nutrition knowledge and the person responsible for nutrition education. The fifth part (10–15 min) focused on the topic of nutrition education for parents, including the desirability of such education. In turn, the sixth part (15–20 min) addressed the materials and communication needs of parents. Such issues were analyzed as: media needed in education, types of publications, scope of content in educational materials, additional aids, and their technical form. Special attention was paid to multimedia and social media. The seventh and final part included a summary of the discussion and gave thanks for participation.

Data analysis

The focus group discussions (FGIs) were audio-recorded with the consent of the participants, which allowed for subsequent analysis of the participants’ verbatim statements (transcriptions)³⁵. Researchers coded and analyzed transcriptions of interviews and notes made during moderation. The material obtained from group discussions was analyzed using the principles of grounded theory, with an emphasis on discovering recurring themes that emerged as a result of group interactions. Data analysis was conducted in a seven-step approach: familiarization with the data, thematic coding, identification of sub-themes within the main framework, review and revision of sub-themes, definition and naming of sub-themes, analysis and interpretation of patterns throughout the data area, and the combination of sub-themes into dominant contextual domains³⁴.

Results

The current level of pupils’ nutrition knowledge

Children are consumers with specific eating behaviors and food choices. When asked about their children’s knowledge and nutritional choices, parents had various opinions on this subject, also pointing to the role of various knowledge sources (Table 2).

Nearly half of the respondents (n=24) indicated that the state of nutrition knowledge for primary schoolchildren is average. The average level of nutrition knowledge was explained by paying attention to selected principles of proper nutrition, quantification of appropriate food products, or the recommended composition of dishes.

Participants of FGIs identifying the level of knowledge as average noted the type of information provided. They suggested increasing practical issues rather than theoretical information. About 28.6% of parents participating in the study indicated that their child had low or minimal nutrition knowledge. Other participants indicated good knowledge of nutrition; however, they identified its theoretical nature.

Sources of primary schoolchildren’s nutrition knowledge

Parents and the family home, school, and the Internet were equally cited as sources of knowledge of food and nutrition held by children (Table 3). The age differentiation is noteworthy; for children, the primary source of knowledge was the family environment, conversations with parents and siblings, preparing meals together, etc. However, this was dependent on parental interest.

The knowledge gained from school stemmed directly from teachers implementing specific curricula and thematic meetings and lectures. Appeals, occasional actions organized by the school, and talks with doctors, nurses, and nutritionists were also pointed out.

For older children, the Internet and conversations with peers become the primary sources of information connected with food and nutrition. Events, youth press, books, and guides were also mentioned, but less often. Thematic meetings, lectures, and cooking programs were also pointed out. In addition, educational and nature programs, as well as popular science magazines, were mentioned among sources of nutrition knowledge.

Social media and influencers as a contemporary source of nutrition knowledge

All parents who participated in FGI’s noted social media’s importance in transmitting food and nutrition knowledge. The role of social media was described as “significant,” “large,” “very large,” “huge,” “enormous,” or “leading,” emphasizing the virtual and unreal world. In this context, children’s living environment was described as a “media/virtual world.” The role of social media in general and in the context of specific portals or sites, including the channels of famous YouTubers and profiles on Facebook, Instagram, and TikTok, was pointed out (Table 4).

In assessing the importance of social media, parents pointed out the impact of social media on children. This influence refers to the transmission of information in various areas of knowledge. They also pointed to the transmission of information through an interesting way for children to spend their time.

The importance of social media should also be assessed in terms of specific content and how it is conveyed. Influencers and the content they create are becoming increasingly important. Children taking an interest in the lives of influencers, assimilate the information they provide. The influence on children also manifests itself in imitating influencers’ behavior, including their nutrition behavior. Influencers become idols for children, increasing their influence and amplifying their potential.

Sources of knowledge	Examples of parents’ statements
Family environment	“Poor-if children have not learned “healthy” eating habits from the family home.”
	“Mostly from home, if parents pay attention.”
Schools and teachers	“Good. We try to convey knowledge. It doesn’t go with behavior, but it is an individual matter for children. Some children are rebels. School is better as a source of knowledge because teachers are authorities and children follow the crowd.”
	“At school, from lessons, from appeals, newspapers, talks with the nurse, from programs implemented at school, e.g., Keep in shape.”
	“In addition to parents, school is the main source of knowledge.”
Press, books	“There were thematic weeks, e.g., fruits, vegetables, water, and the children themselves made sure that for their second breakfasts, there were these products.”
Producers/shops	“My son is allergic to milk, one of the parents conducted training during the classes, so my and the child’s knowledge is satisfactory.”
	“In one of the supermarket chains, there was a booklet on proper nutrition principles (vitamin “team”). Although knowledge does not necessarily meet practice.”
TV, culinary programs	“Most often from television.”
	“Culinary programs, e.g., Jamie Olivier’s cooking. My son started his nutritional education with the film “Once Upon a Life”, also a dietary crime story.”
	“On TV, for example, Polish culinary authorities Karol Okrasa and Magda Gessler.”
Internet	“In the first-place peers and the Internet, now it is very popular on TikTok.”
	“Educational applications relating to various fields. Children learn by playing.”
Various	“The most from parents, from home. In second place is school.”
	“They grow up with parents who, for example, eat healthy and learn from a young age, then activities at school and the Internet.”

Table 3. Sources of schoolchildren’s nutrition knowledge.

Examples of parents' statements
"The importance of social media is huge because children live in a media world, it is a world that is very attractive to children."
"The role of social media is considerable due to the fact that children spend a lot of time watching YouTube and other social media"
"The media plays an important role in today's society. So, they also have an impact on our children's knowledge."
"Students spend a lot of time on social media. The content there has a strong influence on children. They believe what their favorite influencers say."
"Students like and are interested in the lives of influencers, etc."
"Influencers are children's idols and what they pass on to them is an authority for them."
"Now almost everyone has a person they really like, like an idol. And almost every one of the famous bloggers, etc. is living a healthy lifestyle, eating well. Well, and children are also starting to eat healthy because they look up to them."
"Influencers are popular and are idols for children. It's easier for children to listen to someone famous than boring lessons at school."
"In today's digital age, children are influenced by influencers, and they treat them as a model of behavior."
"Children unconsciously imitate their favorite influencers, thus they may be influenced by them, so if a well-known person promotes a healthy lifestyle, children will start to do the same."

Table 4. Social media as a source of primary schoolchildren's nutrition knowledge.

According to parents, the imitation of influencers may be unconscious, related to the desire to gain recognition in their peer group. Therefore, it is important to get the message right and ensure it is about favorable content for children.

The role of parents, schools, and peers in imparting nutrition knowledge among primary schoolchildren

Parents participating in FGI's unanimously pointed to the importance of parents and schools in imparting nutrition knowledge and placed peers in third place.

"Schools should be an important source of knowledge for children, but not the only one. In my opinion, we as parents should be the first to care. Peers may or may not have incomplete knowledge, so I think it is better for them to get this knowledge from other sources."

"Schools and parents should provide children with nutrition knowledge."

"Schools and parents should emphasize this and make youngsters aware of products and proper nutrition."

The importance of parents and teachers in providing nutrition knowledge refers to making children aware, promoting proper shopping behavior, and encouraging appropriate lifestyles.

"Knowledge gained in school alone is not enough. Parents play a huge role here, as children imitate their behavior from an early age."

"Parents in childhood are supposed to "promote" healthy lifestyles; later, children are more susceptible to the opinions of their peers, the so-called "trends," so if it is "fashionable," it will be easier to teach a child to eat healthily and gain knowledge about it."

Method of imparting children's nutrition knowledge

The majority of parents cited a separate food and nutrition subject and talked about nutrition topics in lessons as a form of imparting nutrition knowledge. They also pointed to parenting and biology lessons.

"Lessons in parenting and nature/biology related to this subject, additional actions promoting healthy eating in which children can participate, circles related to healthy eating, lessons in cooking/preparing healthy meals."

Practical aspects of knowledge transfer were pointed out. Workshops, thematic and dedicated lessons, and tours were mentioned.

"There should be workshops where children could learn about the topic interestingly and enjoyably."

"A big plus would be projects where children not only get healthy food but also knowledge about proper nutrition."

"There should be excursions with workshops so that children can learn about production and nutritional principles. This would benefit everyone."

"The classes should be practical, gardens, workshops."

Participants of FGI's pointed to an attractive and practical form implemented on a cyclical basis as a model way of imparting nutrition knowledge. In addition, they postulated the possibility of leaving the children to choose.

"A good idea could be cooking classes, in which children themselves prepare some exceptionally attractive and "proper" dishes."

Persons responsible for imparting nutrition knowledge at school

According to participants of FGI's, those responsible for imparting food and nutrition knowledge should be the class teacher or a person designated for this purpose.

"Schools should hire people to do this who have extensive knowledge of nutrition issues."

A special nutrition teacher, nutritionist, or teacher of subjects such as biology and physical education was also pointed out. Less frequently mentioned were nurses or principals.

"School principal, through the organization of food-related activities and the cafeteria."

"The school should provide a teacher who will be responsible for this."

"Teachers, a psychologist, a biology teacher, a nutritionist, and the principal, who should hire qualified personnel."

Thematic areas of transferred nutrition knowledge for children

The largest group of parents taking part in FGI's (n = 42) pointed to the health-promoting aspects of transmitted food and nutrition knowledge, focusing on the benefits and consequences of a particular diet. Special attention was paid to diet-related diseases (Table 5).

In addition, the composition of food products, including the content of macro and micronutrients, information on processed and modified foods, and the presence of food additives and harmful substances were pointed out. Knowledge of autoimmune diseases was also mentioned. Issues concerning the impact of food production on the climate, the building of the body's immunity, and the prevention of diet-related diseases were indicated as interesting areas of schoolchildren's knowledge about food and nutrition.

Separate topics, including selected diets such as gluten-free, lactose-free, and diabetic diets, were also pointed out by parents as interesting topics that should be included in nutritional education programs. Among the areas of schoolchildren nutrition knowledge, participants pointed to physical activity, taking into account the impact

Topics	Examples of parents' statements
Proper nutrition	<i>"Adequate nutrition, the consequences associated with poor nutrition and the benefits of adequate nutrition, stories of various people such as those who have improved their health through proper nutrition or vice versa."</i>
	<i>"About the influence of fast food on health and "civilization diseases" (diet-related disease)."</i>
	<i>"Consuming excessive amounts of sweet drinks and fast food."</i>
	<i>"What and how much a child should eat, the impact of individual food product groups on health, and what proper nutrition should look like."</i>
	<i>"Instilling proper dietary principles and appropriate selection of products needed for our bodies."</i>
	<i>"The effect of products on the body. Basic knowledge about macro and micronutrients."</i>
Children's diet	<i>"What children should eat more of and what they should eat less of. Positive and negative effects. Also, ingredients. The problem of obesity, to introduce children to the effects of obesity, resulting from eating chips."</i>
	<i>"What types of diets are there and for whom are they intended, how sick people should eat, how many meals they should eat and what they should contain in them, how to choose a meal for the time of day, how to choose products to supplement the need for vitamins and other minerals."</i>
	<i>"Topics about diets: gluten-free, lactose-free, for diabetics."</i>
The influence of nutrition on health	<i>"Issues of building immunity to infections and preventing lifestyle diseases."</i>
	<i>"Knowledge about autoimmune diseases."</i>
Food additives	<i>"Food additives that are harmful to health."</i>
Physical activity	<i>"Sports. In addition, how diet affects our bodies, why it is important to provide the necessary ingredients."</i>
Various	<i>"Balanced meals, the impact on health, physical activity, the impact of sleep on well-being, etc."</i>
	<i>"New flavors, learning about new tastes. Showing new products and having fun in the form of attractions."</i>

Table 5. Parents' opinions on topics that should be included in the nutritional education of their children.

of sports on human health or as a result of their awareness that a healthy lifestyle should be taken into account as a whole, not as separate elements.

Propositions for topics involved in the nutritional education program were also suggested in the areas of salt, sugar, consumption of excessive amounts of sugar drinks, sweets, and products defined as junk food. Topics on consuming the right amount of water also proved important. Water was pointed out as the "source of life and health." Topics related to fats also proved to be important, identified as "About healthy and unhealthy fats." Proper dietary balance related to correct dietary principles was also emphasized. Among the topics mentioned, there were aspects of hygiene, and food production in terms of food preparation, including novelties.

Forms of transmitted nutrition knowledge to schoolchildren

Parents indicated two basic forms for the transmission of children knowledge in the field of food and nutrition, which were identified as traditional and modern (Fig. 1, Table 6). The sources of knowledge were analyzed using Wordle software (www.wordle.net,³⁶). The size of the words and letters is directly proportional to the frequency used in this study. As was expected, the most important sources of food and nutrition knowledge are “social media,” “films,” “books,” and “multimedia forms.”

In terms of the modern form, social media was mentioned, further distinguishing the multimedia form. They pointed to videos, short advertising spots, and social media posts. Attention was paid to specific solutions, such as suggesting a channel on YouTube.

The attractiveness of the multimedia form of knowledge transfer was emphasized, with additional attention paid to practical aspects. Mobile apps were pointed to as a separate medium in the modern form of transferring knowledge on food and nutrition to pupils.

Books, including recipe books, comic books, and how-to books, were mentioned as mediums in the traditional form of transmitting food and nutrition knowledge. Attention was paid to their interesting form, which was related to stimulating children's imagination. As an example, books with stickers were given. Among printed materials, posters, brochures for children and adults responsible for imparting nutrition knowledge were also mentioned as well as gadgets and collecting materials.

Discussion

Increasing levels of obesity as well as underweight schoolchildren all over the world, including Poland, in some cases very dangerous because of the scale as well as numerous diet-related diseases among this subpopulation determine different kinds of activities focused on limiting this disturbing trend^{13,37,38}. One such activity is nutritional education, which should change inappropriate nutritional behavior back towards being appropriate. Within nutritional education, two main institutions responsible for such changes should be mentioned: school and family. Both of them should be aware of the necessity of such education so that they undertake activities focused on changing attitudes toward food and nutrition. FGIs realized among parents from Warsaw showed

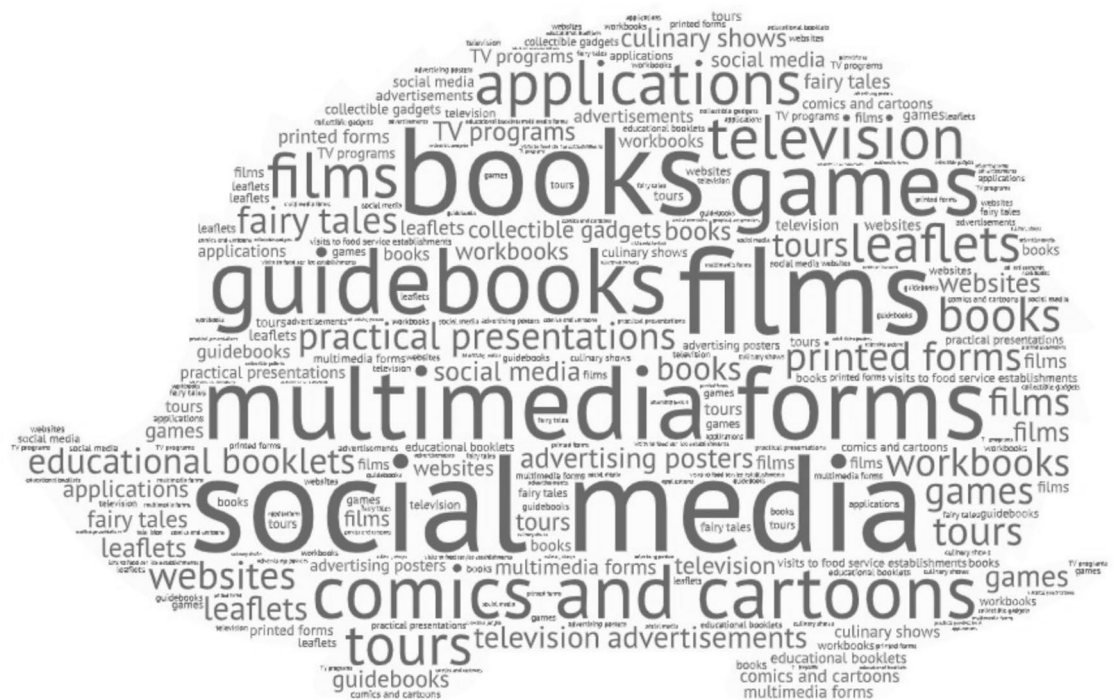


Fig. 1. Analysis of sources of knowledge about food and nutrition among schoolchildren from the parent's perspective.

Form	Examples of parents' statements
Social media	<i>"Nowadays, young people spend their time mainly on social media, so this medium should be used the most in nutrition education."</i>
Videos	<i>"Educational videos for the younger one's cartoons, preferably an episode of some of their favorite cartoons, should be dedicated to nutrition education. Short videos, for example, on YouTube, a channel dedicated to nutrition education conducted in an interesting way, for example, as a mini-series."</i>
	<i>"Due to the generally available phones and other smart devices, they should be available in the form of short, interesting videos."</i>
Mobile apps	<i>"Emphasis on apps and games available on the phone, such as walking around with a human and picking fruit."</i>
	<i>"I am against mobile games; I have seen children become addicted. We control the time we use the Internet. It all has to be under control."</i>
Multimedia	<i>"Apps. If this were information verified by scientific institutions, such messages would be effective. In social media, e.g., Facebook, it is not easy to maintain effectiveness. It should not be text but a photo and a short video—it is engaging and stimulates interest for a short time. The Internet is currently the largest target group."</i>
	<i>"Quizzes for children as multimedia applications such as they have in mathematics. This would interest them more than what they would do on paper."</i>
	<i>"Currently, the most attractive form of learning for children is, of course, multimedia. However, it seems that the most benefits would come from workshops on nutrition, composing meals, and drinking the right amount of water."</i>
Excursions, trips	<i>"The best is the transfer of knowledge in practice through, among other things, excursions, trips to food establishments."</i>
Books, flyers, gadgets	<i>"Books with stickers, children really like books with stickers, what can be collected, what can be colored."</i>
	<i>"Information flyers and brochures may be good sources."</i>
	<i>"Collectible gadgets, such as cards, where you get something in actions, for example, there was something like this in soccer."</i>
Educational games	<i>"There is peer pressure on apps and games available on the phone."</i>
	<i>"Children can learn through play, e.g. educational games."</i>

Table 6. Forms for the transmission of knowledge in the field of food and nutrition to schoolchildren.

that parents are aware of the necessity of nutritional education, reporting different barriers to healthy eating for their children.

They result from a lack of nutrition knowledge among parents and children, a lack of time to prepare a meal, children's personal characteristics as well as preferences and conflicts related to children's likes and dislikes towards food. In the report³⁸, the authors state that more than half of the surveyed Poles do not use any sources of nutrition knowledge and, moreover, they do not apply knowledge about healthy eating in their everyday lives. Other authors^{39,40} point out that programs promoting healthy food in the home environment and social interactions may be useful in supporting the quality of children's diets and making appropriate food choices.

In this study, it has been shown that in addition to traditional sources of acquiring knowledge, such as the home environment, school environment, books, or TV, modern sources are becoming more and more important. These include mobile applications, computer games, social media, YouTube, and information from influencers, where knowledge, combined with an interesting image, can be an attraction for schoolchildren^{41–43}. However, parents must control the separation of true and scientifically proven information from trivial, unverified, or misleading information. The obtained results confirm previous reports by other authors that pupils' knowledge about food and nutrition depends on awareness and practices in nutrition and its sources. The sources of knowledge include mainly family members, friends, the Internet, television, health care workers, books, and textbooks. Online resources have also been shown to be popular, although there are variations in their use and reliability among teenagers^{42,44}. Several studies have found that online resources and social media are the most common sources of nutrition information⁴⁵, however, it has been shown that social media influencers have both negative and positive impacts on health outcomes, with negative impacts seen consistently in studies of body image dissatisfaction⁴³. Moreover, Qutteina et al.⁴⁶, in a systematic review and meta-analysis, demonstrated the significance of media marketing on eating in children and highlighted limitations in the food marketing and adolescent eating literature specific to eating outcomes and marketing media studied. Some of the respondents thought it was a good idea to get information from healthcare professionals. The results of Kundu et al.⁴⁴ suggest that sources of information about pupils' nutrition complement rather than replace each other and that before entering adulthood, they should familiarize themselves with nutritional education, thanks to which they will gain greater freedom in making their own choices as consumers. Other authors indicate that good nutrition knowledge results in the identification of nutritional facts and is strongly related to making healthy food choices⁴⁷.

An important aspect that the respondents paid attention to was preparing and eating meals together. The benefits of eating meals together, especially at home with the family, concern psychosocial areas (lower risk of eating disorders)^{48,49} as well as healthier eating patterns (e.g., higher consumption of fruit and vegetables and lower consumption of sugar-sweetened beverages)⁵⁰.

Parents indicate that they also need nutritional education, as they are somewhat lost in the abundance of media information. They lack knowledge about proper child nutrition and its impact on children's health, information about the composition of food, and, in particular functional additives.

The diet of schoolchildren is the result of a complex interaction of various factors, including the nutritional environment⁵¹, in which consumers, including the youngest, interact with food systems in order to purchase food⁵². In the food trade, many strategies (placement, promotions, packaging, and advertising) influence consumer choices²⁰. The omnipresent persuasive marketing has a particularly strong presence on television and radio, websites⁵³, and games^{42,54} and extends its promotion to supermarkets and other points of sale^{55,56} as well as other places outside schools such as outdoors (billboards, posters, and moving vehicles)⁵⁷, resulting in minimal uncommercialized space in children's and adolescent's environments. Providing nutritional education can improve the home food environment for children and their families⁵⁸. Combining both school and home environments could be a good reinforcement of nutrition information in shaping future nutrition-conscious and socially responsible consumers who care about sustainable consumption, and especially a sustainable diet.

Strengths, limitations, and future studies

However, there are some limitations to the research. Firstly, the study sample was limited to Warsaw (Poland), which may reduce the generalizability of the findings. There may be other confounding factors (like lifestyle, living in a large city, parental age and education, and greater opportunities to participate in various extracurricular activities as well as better macroeconomic indicators) that could influence the findings of this study. It should be emphasized, however, that the richness and diversity of the data obtained in the Focus Group Interview (FGI) among parents is a valuable method of gaining information about children's opinions, preferences, and attitudes.

On the other hand, although the data obtained using this technique are not quantitative, which makes it difficult to analyze participants' responses, and the group dynamics influence the responses of others (some of the group's suggestions may be inappropriate), these aspects constitute the strength of qualitative research such as FGI.

The data obtained through loose statements and discussions during the FGIs are the main benefit of this study and can be helpful for creating guidelines/recommendations for schools in terms of the pro-health education provided^{59,60} as well as creating more socially responsible advertising that promotes healthy eating.

Future research could consider using quantitative studies among children and their families from different socioeconomic and geographical environments and in relation to various aspects of a healthy lifestyle.

Conclusion

Nutrition education for children based on the scientific basis may be one of the most essential actions that should be taken to protect children from the harmful impact of food marketing and to prevent the risk of obesity and other non-communicable chronic diseases.

Nutrition education, by definition, leads to a change in children's attitudes towards food and nutrition, especially their nutrition behavior. Based on the qualitative results of FGIs conducted among parents of pupils from primary schools located in Warsaw, the capital city of Poland, we explored some research problems that we formulated as the most important within our moderation scenario. As we noticed, based on qualitative research among parents, nutrition education should focus on aspects like proper nutrition, children's specialized diets, the influence of nutrition on health, food additives, and healthy lifestyles, including physical activity, screen time, and sleep time.

About half of parents who participated in FGIs indicated that their children's nutrition knowledge is average. The average level of knowledge was explained by paying attention to knowledge relating to selected principles of proper nutrition, quantification selection of appropriate food products, or the recommended proper composition of dishes. The largest group of participants suggested increasing practical issues rather than theoretical ones. Generally, based on parents' opinions, we observed that they are, as well as the family home, school, and the Internet, equally cited as sources of nutrition knowledge held by children. The age differentiation is noteworthy; for the youngest children, the main source of knowledge was the family environment, conversations with parents and siblings, preparing meals together, etc. For older children, the Internet and peers become the primary source of information connected with food and nutrition. Events, youth press, books, and guides were also mentioned but less often. Thematic meetings, lectures, and cooking programs were also pointed out. In addition, educational and nature programs and popular science magazines were mentioned among sources of nutrition knowledge.

It should also be emphasized that screen time should be limited because otherwise, it leads to more frequent snack intake, which in the end leads to being overweight or obese. As parents indicated, to transform nutrition knowledge in children, they should use IT tools because they are inherent elements of their daily lives. Therefore, various activities are necessary to implement nutritional education for children, including traditional tools (books, TV, etc.) as well as modern IT tools (social media) and telecommunications tools (mobile apps) used under the control of parents/teachers. Appropriate knowledge about food and nutrition can lead to more conscious food choices by children and the entire family, especially parents. Parents mentioned during FGIs that they lack knowledge about proper child nutrition, food composition, including functional additives, and their impact on children's health. Therefore, it is a significant factor affecting society's public health because food selection and eating behavior can profoundly affect diet during growth and across the entire lifespan and play a crucial role in lifelong health and well-being.

The results provide a theoretical basis for undertaking intervention measures based on the family and school, including those concerning the entire food market and consumer choices. We can also underline that nutritional education should be addressed to children and parents to improve their awareness of the importance

of nutritional education in practice by cooking at home with a quasi-scientific introduction explaining the role of nutrients in food used to prepare meals, what can be an example of “non-formal” nutrition education at home.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Received: 7 August 2024; Accepted: 8 May 2025

Published online: 19 May 2025

References

1. Finnane, J. M., Jansen, E., Mallan, K. M. & Daniels, L. A. Mealtime structure and responsive feeding practices are associated with less food fussiness and more food enjoyment in children. *J. Nutr. Educ. Behav.* **49**, 11–18.e1. <https://doi.org/10.1016/j.jneb.2016.08.007> (2017).
2. Montañó, Z., Smith, J. D., Dishion, T. J., Shaw, D. S. & Wilson, M. N. Longitudinal relations between observed parenting behaviors and dietary quality of meals from ages 2 to 5. *Appetite* **87**, 324–329. <https://doi.org/10.1016/j.appet.2014.12.219> (2015).
3. Arafa, A. et al. Lifestyle behaviors of childhood and adolescence: contributing factors, health consequences, and potential interventions. *Am. J. Lifestyle Med.* <https://doi.org/10.1177/15598276241245941> (2024).
4. Genovesi, S. et al. Prevention of cardiovascular diseases in children and adolescents. *High Blood Pressure Cardiovasc. Prev.* **26**, 191–197. <https://doi.org/10.1007/s40292-019-00316-6> (2019).
5. Liorret, S. et al. Lifestyle patterns begin in early childhood, persist, and are socioeconomically patterned, confirming the importance of early life interventions. *Nutrients* **12**(3), 724. <https://doi.org/10.3390/nu12030724> (2020).
6. Mahmood, L. et al. Parental food consumption and diet quality and its association with children's food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study. *Public Health Nutr.* **25**(12), 3344–3355. <https://doi.org/10.1017/S1368980022002245> (2022).
7. Czarniecka-Skubina, E., Gutkowska, K. & Hamulka, J. The family environment as a source for creating the dietary attitudes of primary school students—a focus group interview: the Junior-Edu-Żywnie (JEŻ) Project. *Nutrients* **15**, 4930. <https://doi.org/10.3390/nu15234930> (2023).
8. Czarniecka-Skubina, E., Hamulka, J. & Gutkowska, K. How can we increase the nutrition-related knowledge in children aged 7–12 years: results of focus groups interviews with parents—the Junior-Edu-Żywnie (JEŻ) Project. *Nutrients* **16**, 129. <https://doi.org/10.3390/nu16010129> (2024).
9. Gray, H. L., Buro, A. W. & Sinha, S. Associations among parents' eating behaviors, feeding practices, and children's eating behaviors. *Maternal Child Health J.* **27**(2), 202–209. <https://doi.org/10.1007/s10995-022-03572-6> (2023).
10. Medeiros, G. C. B. S. et al. Effect of School-based food and nutrition education interventions on the food consumption of adolescents: a systematic review and meta-analysis. *Int. J. Environ. Res. Public Health* **19**, 10522. <https://doi.org/10.3390/ijerph191710522> (2022).
11. Kupka, R., Siekmans, K. & Beal, T. The diets of children: overview of available data for children and adolescents. *Glob. Food Secur.* **27**, 100442. <https://doi.org/10.1016/j.gfs.2020.100442> (2020).
12. World Health Organization (WHO). Follow-up to the political declaration of the third high-level meeting of the General Assembly on the prevention and control of non-communicable diseases. Seventy-Fifth World Health Assembly, No A75/10 Add.5, Annex 11 (2022).
13. World Health Organization (WHO). Obesity and overweight. Fact sheets (2024, accessed 17 Nov 2024). <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>.
14. WHO European Regional Obesity Report 2022. Copenhagen: WHO Regional Office for Europe; 2022. License: CC BY-NC-SA-3.0 IGO (2024, accessed 17 Nov 2024). <https://www.who.int/europe/publications/i/item/9789289057738>.
15. OECD/European Union. Physical activity among children and adolescents. In *Health at a Glance: Europe 2020: State of Health in the EU Cycle* (OECD Publishing, 2020). <https://doi.org/10.1787/5ee82799-en>.
16. Jensen, M. L. et al. Television viewing and using screens while eating: associations with dietary intake in children and adolescents. *Appetite* **168**, 105670. <https://doi.org/10.1016/j.appet.2021.105670> (2022).
17. Khomsan, A., Anwar, F., Riyadi, H. & Navratilova, H. F. Children's food habits, consumption, and food safety of popular snacks in school environment in Indonesia. *Int. J. Commun. Med. Public Health* **10**(1), 119–125. <https://doi.org/10.18203/2394-6040.ijcmp.h20223535> (2023).
18. Li, Y. Food advertisement and its influence on childhood obesity. *Highlights Sci. Eng. Technol.* **11**, 210–217. <https://doi.org/10.54097/hset.v11i.1377> (2022).
19. Yang, C. et al. Snacking behaviour and nutrients intake among 11–16 years-old students from two different boarding system schools. *Heliyon* **9**(3), e14517. <https://doi.org/10.1016/j.heliyon.2023.e14517> (2023).
20. Smith, R., Kelly, B., Yeatman, H. & Boyland, E. Food marketing influences children's attitudes, preferences and consumption: a systematic critical review. *Nutrients* **11**, 875. <https://doi.org/10.3390/nu11040875> (2019).
21. Sohail, R. et al. The influence of the home food environment on the eating behaviors, family meals, and academic achievement of adolescents in schools in the UAE. *Int. J. Environ. Res. Public Health* **21**(9), 1187. <https://doi.org/10.3390/ijerph21091187> (2024).
22. Pourmoradian, S. et al. Television food advertisements and childhood obesity: a systematic review. *Int. J. Vitam. Nutr. Res.* **91**(1), 1–7. <https://doi.org/10.1024/0300-9831/a000681> (2020).
23. Sramova, B. Children's consumer behavior. Chapter 6. In *Consumer Behavior- Practice Oriented Perspectives*. <https://doi.org/10.5772/intechopen.69190> (2017).
24. Neufeld, L. M. et al. Food choice in transition: adolescent autonomy, agency, and the food environment. *The Lancet* **399**, 185–197. [https://doi.org/10.1016/S0140-6736\(21\)01687-1](https://doi.org/10.1016/S0140-6736(21)01687-1) (2022).
25. Janssen, H. G., Davies, I. G., Richardson, L. D. & Stevenson, L. Determinants of takeaway and fast food consumption: a narrative review. *Nutr. Res. Rev.* **31**(1), 16–34. <https://doi.org/10.1017/S0954422417000178> (2018).
26. Sajdakowska, M., Gutkowska, K., Kosicka-Gębska, M., Gębski, J. & Gantner, A. Association between physical activity, diet quality and leisure activities of young poles. *Nutrients* **15**, 5121. <https://doi.org/10.3390/nu15245121> (2023).
27. Gutkowska, K., Czarniecka-Skubina, E., & Hamulka, J. Is nutritional education in primary schools needed in the light of teachers' diagnosis of the state of knowledge about food and nutrition of 7–12-year-old primary school pupils? The Focus Group Interview-Junior-Edu-Żywnie (JEŻ) Project. *Ann. Agric. Environ. Med.* <https://doi.org/10.26444/aaem/186511> (2024).
28. Krueger, R. A., & Casey, M. A. *Focus Groups: A Practical Guide for Applied Research* (5th ed.) (SAGE Publications, 2015).
29. Stewart, D. W. & Shamdasani, D. M. *Focus Groups: Theory and Practice* 3rd edn. (Sage Publications, 2015).
30. Hamulka, J., Czarniecka-Skubina, E., Gutkowska, K., Drywień, M. E. & Jeruszka-Bielak, M. Nutrition-related knowledge, diet quality, lifestyle, and body composition of 7–12-years-old Polish students: study protocol of national educational project Junior-Edu-Żywnie (JEŻ). *Nutrients* **16**(1), 4. <https://doi.org/10.3390/nu16010004> (2024).

31. Jończy, R. et al. Environmental and economic factors of migration from urban to rural areas: evidence from Poland. *Energies* **14**, 8467. <https://doi.org/10.3390/en14248467> (2021).
32. Klatka, M., Zienkiewicz, E., Koflataj, W., Zienkiewicz, T. & Koflataj, B. Socio-economic development, level of urbanization and consumption of selected food products as factors in the prevalence of overweight and obesity among youths and young adults in Poland. *Ann. Agric. Environ. Med.* **27**(1), 139–145. <https://doi.org/10.26444/aaem/112373> (2020).
33. Suder, A. et al. Prevalence and factors associated with thinness in rural polish children. *Int. J. Environ. Res. Public Health* **17**(7), 2368. <https://doi.org/10.3390/ijerph17072368> (2020).
34. Berg, B. L. *Qualitative Research Methods for the Social Sciences* (Allyn & Bacon, 2001).
35. Strauss, A. & Corbin, J. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques* (Sage Publications, Ltd, 1990).
36. Wordle software (2024, accessed 30 Jun 2024). www.wordle.net.
37. Mazur, J., & Małkowska-Szcutnik, A. Zdrowie uczniów w 2018 roku na tle nowego modelu badań HBSC. Instytut Matki i Dziecka, Warszawa (2018).
38. Wojtyński, B., & Goryński, P. Health status of Polish population and its determinants. In *National Institute of Public Health—National Institute of Hygiene, Warsaw* (2022).
39. Fulkerson, J. A. et al. Family home food environment and nutrition-related parent and child personal and behavioral outcomes of the HOME Plus study: a randomized controlled trial. *J. Acad. Nutr. Dietet.* **118**(2), 240–251. <https://doi.org/10.1016/j.jand.2017.04.006> (2018).
40. Shema, N., Jagmeet, M. & Panchali, M. Nutritional knowledge of the parents and home food environment of 10 to 12 year old children of Mumbai. *Int. J. Physiol. Nutr. Phys. Educ.* **4**(2), 114–119 (2019).
41. Coates, A. E., Hardman, C. A., Halford, J. C. G., Christiansen, P. & Boyland, E. J. Social media influencer marketing and children's food intake: a randomized trial. *Pediatrics* **143**(4), e20182554. <https://doi.org/10.1542/peds.2018-2554> (2019).
42. Evans, R. K. et al. A systematic review and meta-analysis of the effect of digital game-based or influencer food and non-alcoholic beverage marketing on children and adolescents: exploring hierarchy of effects outcomes. *Obes. Rev.* **24**(12), e13630. <https://doi.org/10.1111/obr.13630> (2023).
43. Powell, J. & Pring, T. The impact of social media influencers on health outcomes: systematic review. *Soc. Sci. Med.* **340**, 116472. <https://doi.org/10.1016/j.socscimed.2023.116472> (2024).
44. Kundu, S. et al. Sources of nutrition information and nutritional knowledge among school-going adolescents in Bangladesh. *Public Health Practice* **1**, 100030. <https://doi.org/10.1016/j.puhip.2020.100030> (2020).
45. Kucharczuk, A. J., Oliver, T. L. & Dowdell, E. B. Social media's influence on adolescents' food choices: a mixed studies systematic literature review. *Appetite* **168**, 105765. <https://doi.org/10.1016/j.appet.2021.105765> (2022).
46. Quetteina, Y., Hallez, L., Mennes, N., De Backer, C. & Smits, T. What do adolescents see on social media? A dairy study of food marketing images on social media. *Front. Psychol.* **10**, 2637. <https://doi.org/10.3389/fpsyg.2019.02637> (2019).
47. Kalog, G. L. S. et al. Food advertisement influences food decision making and not nutritional status: a study among university students in Ghana. *BMC Nutr.* **8**(1), 72. <https://doi.org/10.1186/s40795-022-00571-2> (2022).
48. Glanz, K., Metcalfe, J. J., Foltz, S. C., Brown, A. & Fiese, B. Diet and health benefits associated with in-home eating and sharing meals at home: a systematic review. *Int. J. Environ. Res. Public Health* **18**(4), 1577. <https://doi.org/10.3390/ijerph18041577> (2021).
49. Langdon-Daly, J. & Serpell, L. Protective factors against disordered eating in family systems: a systematic review of research. *J. Eating Disord.* **5**, 12. <https://doi.org/10.1186/s40337-017-0141-7> (2017).
50. Fulkerson, J. A., Larson, N., Horning, M. & Neumark-Sztainer, D. A review of associations between family or shared meal frequency and dietary and weight status outcomes across the lifespan. *J. Nut. Educ. Behav.* **46**, 2–19. <https://doi.org/10.1016/j.jneb.2013.07.012> (2014).
51. Downs, S., & Demmler, K. M. Food environment interventions targeting children and adolescents: a scoping review. *Glob. Food Secur.* **27**, 100403. <https://doi.org/10.1016/j.gfs.2020.100403> (2020).
52. Downs, S. M., Ahmed, S., Fanzo, J. & Herforth, A. Food environment typology: advancing an expanded definition, framework, and methodological approach for improved characterization of wild, cultivated, and built food environments toward sustainable diets. *Foods* **9**(4), 532. <https://doi.org/10.3390/foods9040532> (2020).
53. Potvin Kent, M. & Pauzé, E. The frequency and healthfulness of food and beverages advertised on adolescents' preferred websites in Canada. *J. Adolesc. Health* **63**, 102–107. <https://doi.org/10.1016/j.jadohealth.2018.01.007> (2018).
54. Maksi, S. J. et al. The food and beverage cues in digital marketing model: special considerations of social media, gaming, and live streaming environments for food marketing and eating behavior research. *Front. Nutr.* **10**, 1325265. <https://doi.org/10.3389/fnut.2023.1325265> (2024).
55. Boyland, E. J. et al. Advertising as a cue to consume: a systematic review and meta-analysis of the effects of acute exposure to unhealthy food and nonalcoholic beverage advertising on intake in children and adults. *Am. J. Clin. Nutr.* **103**(2), 519–533. <https://doi.org/10.3945/ajcn.115.120022> (2016).
56. Dikmen, D. et al. Cross-sectional evaluation of food items preferred by adolescents under the influence of television advertisements. *J. Res. Health Sci.* **22**(1), e00539. <https://doi.org/10.34172/jrhs.2022.74> (2021).
57. Jordan, R., Garton, K. & Mackay, S. Testing a nutrient composition threshold model to classify brands for marketing restrictions. *PLoS ONE* **19**(10), e0311579. <https://doi.org/10.1371/journal.pone.0311579> (2024).
58. Hernandez, M. M. Y., Februhartanty, J., & Bardosono, S. Association between food marketing exposure and consumption of confectioneries among pre-school children in Jakart. *Malaysian J. Nutr.* **25**(Supl.), 63–73 (2019).
59. Hall, E., Chai, W. & Albrecht, J. A. A qualitative phenomenological exploration of teachers' experience with nutrition education. *Am. J. Health Educ.* **47**(3), 136–148. <https://doi.org/10.1080/19325037.2016.1157532> (2016).
60. Stage, V. C. et al. Eastern North Carolina Head Start Teachers' personal and professional experiences with healthy eating and physical activity: a qualitative exploration. *Public Health Nutr.* **24**(11), 3460–3476. <https://doi.org/10.1017/S1368980020003687> (2021).

Author contributions

K.G., E.CzS., H.GW. and J.H. wrote the main manuscript and prepared Tables 1–6. H.GW. prepared Fig. 1. K.G., E.CzS. and J.H.—created conceptualization and methodology. K.G., E.CzS., H.GW. and J.H. collected data. K.G., E.CzS. and J.H.—funding acquisition, supervision. K.G.—project administration. E.CzS. and J.H.—visualization. All authors have read and agreed to the published version of the manuscript.

Funding

This research was financially supported by the Polish Ministry of Education and Science (Agreement No: MEiN/2022/DPI/96 of 7 March 2022). The task entitled 'Conducting scientific research in the field of nutrition of children and adolescents, developing and implementing a nutritional education program for pupils of grades 1–6 of primary schools. Acronym: Junior-Edu-Żywnienie (JEŻ)'.

Competing interests

The authors declare no competing interests.

Ethical approval

The project followed the ethical standards recognized by the Helsinki Declaration. The study protocol was also approved by the Ethics Committee of the Institute of Human Nutrition Sciences of the Warsaw University of Life Sciences (Resolution No. 18/2022).

Additional information

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