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# Unhealthy Food and Beverage Marketing to Children in the Digital Age: Global Research and Policy Challenges and Priorities

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## Abstract

Food and nonalcoholic beverage marketing is implicated in poor diet and obesity in children. The rapid growth and proliferation of digital marketing has resulted in dramatic changes to advertising practices and children's exposure. The constantly evolving and data-driven nature of digital food marketing presents substantial challenges for researchers seeking to



quantify the impact on children and for policymakers tasked with designing and implementing restrictive policies. We outline the latest evidence on children’s experience of the contemporary digital food marketing ecosystem, conceptual frameworks guiding digital food marketing research, the impact of digital food marketing on dietary outcomes, and the methods used to determine impact, and we consider the key research and policy challenges and priorities for the field. Recent methodological and policy developments represent opportunities to apply novel and innovative solutions to address this complex issue, which could drive meaningful improvements in children’s dietary health.

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**1. INTRODUCTION**

Dietary risks and obesity are leading causes of mortality globally (54). More than 340 million young people (5–19 years old) worldwide were living with overweight or obesity in 2016, representing a dramatic increase in the prevalence of excess weight in the last four decades (85). These trends have been attributed to changes in the global food system, dictated by dominant transnational food corporations producing highly processed, energy dense, palatable foods and beverages, which are effectively and aggressively marketed (123).



Children and adolescents are an important consumer segment for marketers because they spend substantial amounts of their own money, heavily influence household spending, and are future adult consumers (122). They are also thought to be particularly susceptible to unhealthy food and nonalcoholic beverage (hereafter referred to as food) marketing due to a range of neurocognitive, hormonal, and social developmental factors (140). Food marketing has been causally linked to obesity in children (89). Therefore, the protection of young people from unhealthy food marketing is a global policy priority for the prevention of obesity, dietary risks, and associated noncommunicable diseases (144).

The International Network for Food and Obesity/Non-communicable Diseases Research, Monitoring, and Action Support (INFORMAS) is a global network that aims to monitor, benchmark, and support policy actions to improve food environments, including food marketing. Recent INFORMAS reviews have explored methods for monitoring children's exposure to food marketing across a range of media and settings (71) and synthesized cross-country comparisons of television advertising monitoring studies that applied INFORMAS protocols (76).

Policy recommendations call on governments to gather, or support the collection of, evidence of marketing impacts as well as exposure and persuasive power (138), as these data are relevant to several stages of the public health policy development cycle (37), yet currently there is no guidance for appraising the impact of food marketing on diet-related outcomes in children.

Although multiple evidence syntheses and meta-analyses relating to the impact of food marketing on diet-related outcomes in children are available, most are dominated by studies exploring television advertising only (e.g., 19, 107) and lack evidence from low- and middle-income countries (LMICs) (142, 144). Meanwhile, the World Health Organization (WHO) has highlighted digital food marketing in particular as a “growing concern” (144, p. 4) that is challenging to regulate effectively given its personalized, targeted, rapidly shifting, and data-driven nature (137). In support of this, recent studies document high levels of unhealthy food marketing across many digital platforms (21, 98) and concerning levels of exposure among children globally (72, 87, 100).

This review provides a timely synthesis of the evidence to date of how digital food marketing is experienced by children, its impacts on their food behaviors and health, the methods and approaches that have been used to measure that impact, and the research and policy challenges and priorities that have arisen as a result. The overarching aims of this review are to (a) guide researchers in designing studies to advance our understanding of the impact of food marketing in digital spaces on diet-related outcomes, (b) highlight anticipated future research directions and challenges, and (c) support policymakers to develop and evaluate policies to protect children from digital forms of unhealthy food marketing.

## 2. HOW DIGITAL FOOD MARKETING IS DELIVERED TO AND EXPERIENCED BY CHILDREN

### 2.1. Digital Media Use Among Children

Children spend a significant part of their leisure time online, accessing digital content on mobile phones, tablets, laptops, and desktop computers, often using multiple devices at once (103). A recent study indicated that almost all UK children aged 3–17 years (99%) are online, and rates of digital device ownership are high even among younger children; 60% of children aged 8–11 years in the United Kingdom own their own mobile devices (91). Similarly, in the United States, 97% of children aged 3–18 years have the means to go online (84), while device ownership statistics reveal that 43% of children aged 8–12 years and 88% of adolescents aged 13–18 years in the United States own their own smartphone (103). Children aged 8–12 years in the United States dedicate



approximately 5.5 h on average to screen time daily, while for adolescents aged 13–18 years it is nearly 9 h (103).

Accessing digital content on social media or video sharing platforms (e.g., YouTube or TikTok) are common activities, and most children under 13 years old have their own social media accounts, despite stated age restrictions (91, 108). The use of social media among youth is pervasive; approximately 40% of US children aged 8–12 years and 84% of adolescents aged 13–18 years report having used such platforms (103). Online gaming activities are also frequently used among youth, and, in the United Kingdom, 60% of children aged 3–17 played such games in 2021 (91). In the United States, data indicate that, on average, boys aged 8–18 years dedicate approximately 2.5 h per day to gaming activities, whether on mobile devices, computers, or gaming consoles (103). Children also engage with other digital content, including subscription video-on-demand services (e.g., Netflix, Amazon Prime), streaming television, and messaging applications, among others (91).

## 2.2. Digital Food Marketing: Definition

Marketing is defined by the WHO as “any form of commercial communication or message that is designed to, or has the effect of, increasing the recognition, appeal and/or consumption of a particular product or service” (139, p. 9). Digital food marketing therefore includes all promotional content for foods viewed on digital devices. It differs from traditional advertising in that it “seeks to maximize impact through creative and/or analytical methods” (137, p. 11). Such creative and often interactive methods include the use of social media influencers and online communities popular with children, games, virtual reality environments, and encouraging engagement with content through liking, sharing, and commenting.

## 2.3. Digital Food Marketing Expenditure

Worldwide, digital advertising expenditures totaled \$522.5 billion in 2021, and this is expected to grow to \$836 billion by 2026 (120). While food advertising expenditures remain highest on television, advertising expenditures have been shifting to digital media, where advertising costs are lower and impact is potentially higher (17, 99). Significant increases in digital food marketing advertising spend have been recently reported. For instance, data from the United Kingdom indicate that digital static display (i.e., nonvideo) food advertising expenditures increased by 40% between 2020 and 2021 (121).

## 2.4. Understanding the Digital Food Marketing Ecosystem

Marketing in the digital media ecosystem has evolved into a highly targeted system predicated on tracking and targeting young people. Marketers capitalize on children as consumers in these digital environments, often without parents’ knowledge or consent. A significant amount of data is collected from children’s activities online. User profiles are generated using detailed data on browsing activity, likes, comments, and geographic location in addition to standard demographic information (137). These data are collected and sold in packaged formats to advertisers who use them to design and deliver personalized marketing to maximize engagement (90). Digital food marketing is unique in the use of data, whereby sophisticated algorithms, analytics, and artificial intelligence are harnessed to target specific users with specific content based on their previous online behaviors, sociodemographic profiles, geographic location, and more (80, 137).

One example of the exploitation of children’s online data is neuromarketing, whereby cameras record consumers’ facial responses and identify emotional responses to ads. Emotion analysis methods are being developed to increase the impact of digital marketing (24). Marketers also

**Table 1 Key forms of digital food marketing**

| Name of digital marketing form | Brief explanation of digital marketing form   |
|--------------------------------|---|
| Owned media                    | A food company places marketing content within its own media space, e.g., on their website or social media accounts   |
| Paid media                     | A commercial transaction, monetary or nonmonetary, takes place between a food company and a content creator (e.g., influencer) or publisher (e.g., a third-party digital platform), such as banner advertising on a webpage or a sponsored post on social media |
| Earned media                   | Word-of-mouth marketing   |

use ad placement optimization to identify optimal geographic locations and times to target internet users. These creative tactics encourage consumers to immediately respond to their emotional state by choosing (unhealthy) foods nearby. These strategies are at the heart of frameworks used by marketers to maximize the effectiveness of their promotions, including the RACE (reach, act, convert, engage) framework, which encourages marketers to invest in always-on media to grow their audience and to focus on persuasion marketing to encourage sales (29).

### 2.5. Children’s Exposure to and Engagement with Digital Food Marketing

Digital food marketing can take many forms; an overview is provided in **Table 1**.

Food companies advertise on many online platforms, including social media platforms, food delivery applications, video-on-demand services, streaming television, video sharing platforms, in-game and game-streaming platforms, and immersive virtual reality environments (7, 21, 23, 67, 133). A study investigating food and beverage marketing on live stream gaming platforms (i.e., Twitch, YouTube Gaming, and Facebook Gaming) found that food and beverage brand mentions on these platforms greatly increased over a 17-month period (between 2019 and 2020), and of the six food product categories examined, the most frequently mentioned categories across all platforms were energy drinks (74%), restaurants (9%), and soda (8%) (42). Paid marketing through influencers often occurs through a sponsorship deal whereby the influencer integrates food brands and products into their posts/content. For instance, a study that examined YouTube influencers who appealed to children aged 5–15 years in the United Kingdom revealed that the majority (92.6%) of their videos featured food or beverage cues, many of which were branded and unhealthy (33). Children frequently perceive influencers as dependable and credible sources of information, due to their large following and celebrity status, (38) and have difficulty recognizing brand endorsements as marketing instances (38).

It has been estimated in both Canada and Mexico that children are exposed to more than 1,500 digital food ads per year (87, 100), while adolescents are reported to be exposed to more than 8,500 ads per year in both Australia and Canada (72, 100). In each of these studies, more than 90% of the foods to which youth were exposed were unhealthy (72, 87, 100).

### 2.6. Children’s Recognition and Understanding of Digital Marketing

Children and adolescents display limited recognition and understanding of digital marketing (93). One meta-analysis found that children’s understanding of advertising was limited, specifically that they might recognize that commercials aim to sell something but often do not understand the persuasive intent—that is, the promotion of positive brand/product attributes and the suppression of negative ones in order to persuade (93). A systematic review found that ad recognition appeared to increase with age, though the studies ( $N = 8$ ) were mostly conducted in youth younger than 12 years, and many of the studies had some concerns of bias (93).

Digital ads often blur the line between marketing and entertainment and are designed in ways that may bypass conscious awareness and instead engage emotional and unconscious processing systems. The persuasion knowledge model suggests that, to defend oneself against the effects of advertising, it is critical to recognize that a commercial is trying to sell something (52) and that someone is paying for the advertisement to try to persuade viewers to purchase the item. Understanding advertising tactics and the biases present in advertising (e.g., how the product is portrayed versus its actual qualities) is also considered essential in resisting the effects of advertising. The food marketing defense model posits similar prerequisites for defending against marketing effects: awareness, understanding, cognitive ability to resist commercials, and motivation to defend against commercials (62). Yet, few frameworks and empirical studies have examined whether and how children and adolescents defend against digital marketing. From a theoretical perspective, it may be interesting to conduct further research on the development of recognition and understanding of the commercial intent of food marketing online. However, importantly for policy development, this understanding does not likely confer protection. Meta-analyses of marketing impacts find a positive effect of advertising on attitudes toward brands and products regardless of age (93).

### 2.7. Children's Engagement with Digital Food Marketing

Young people's limited recognition and understanding of marketing content—particularly those viewed on digital formats—is especially concerning given that children and adolescents report positive attitudes and high levels of engagement with digital food marketing. Coates et al. (35), for example, conducted focus groups with 24 British children aged 10–11 years who reported positive attitudes toward influencers, including that influencers seemed accessible and “fill[ed] a gap” in their lives (35, p. 6). Notably, children reported feeling influenced by unhealthy food ads promoted by influencers but felt they were able to resist it, which is clearly at odds with the outcomes of experimental research showing behavioral impacts of influencer marketing in children (see Sections 3.2 and 3.3). Another survey of 1,564 US adolescents aged 14–17 years indicated that 70% of youth had engaged with a food brand (e.g., via likes, follows, or comments) (47). One descriptive study reported that a sample of 27 food and beverage brands on Instagram and Twitter attracted 6.2 million adolescent followers (106), and food brands that targeted Black youth had a higher percentage of Black followers than did other food brands (105).

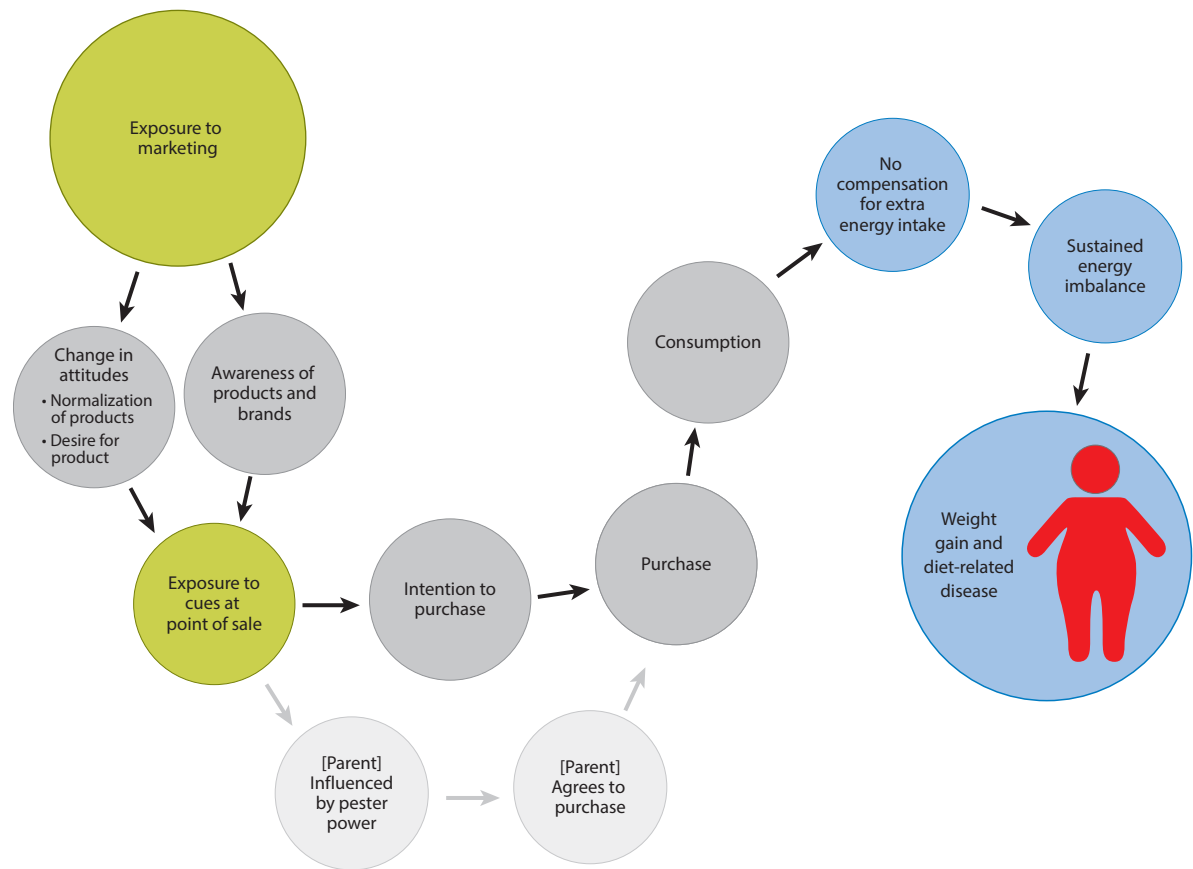
Another research team conducted an observational analysis of positive, negative, and neutral comments about Wendy's (a fast-food chain) on the video-game live streaming platform Twitch before, during, and after Wendy's live streaming ad campaign on the platform (65). They found more positive comments during the campaign period compared with other periods and lower negative comments immediately after the campaign period, suggesting sustained positive impact. Although Twitch has a young demographic base, the study was not able to collect demographic data. A separate study of Twitch users in the United States ( $N = 621$ ) found that users (69% younger than age 25 years) were significantly more likely to report favorable attitudes toward food ads (e.g., believing they help support content creators) compared with YouTube viewers, who reported believing the ads were designed to support the platform (97).

## 3. IMPACT OF DIGITAL FOOD MARKETING ON CHILDREN'S HEALTH AND WELL-BEING

### 3.1. Conceptual Frameworks of Food Marketing Impacts

Several conceptual frameworks and theoretical models guide research questions and draw meaning from research findings across diverse outcomes associated with food marketing impact, for example, the hierarchy of effects model (**Figure 1**) (75).



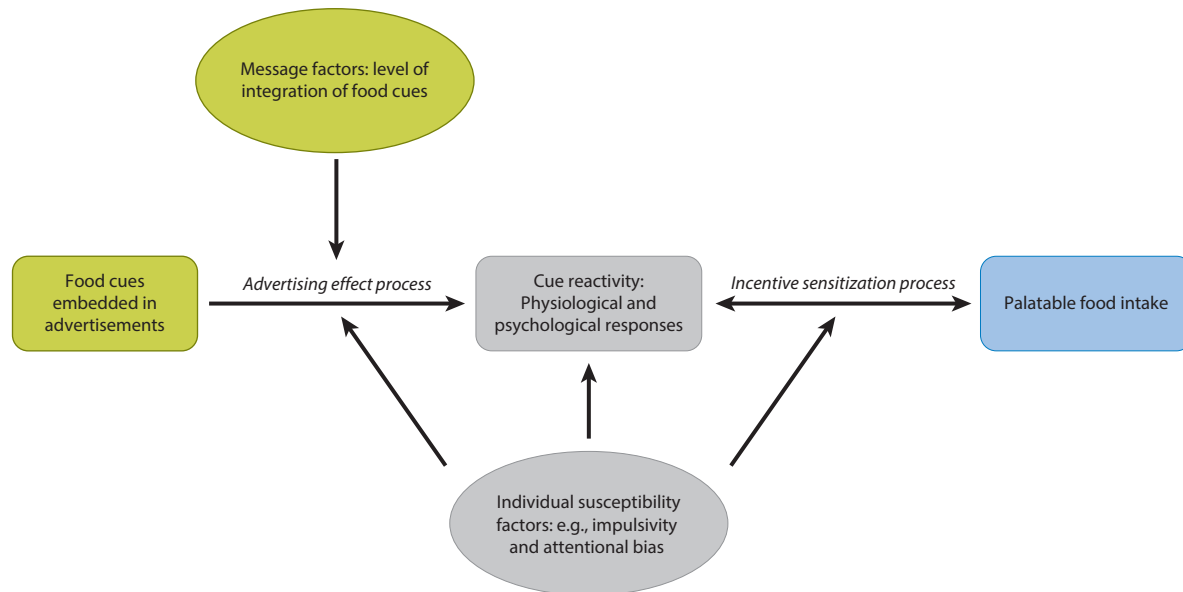


**Figure 1**

Hierarchy of effects model, which proposes an ordered cascade of responses to food marketing exposure including cognitive, attitudinal, affective, behavioral, and health outcomes. Figure adapted with permission from Kelly et al. (75).

Other hierarchical stimulus-response models of marketing effects exist within marketing literature, including the hierarchy of advertising effects (8) and customer-based brand equity (31). These models propose that marketing leads to brand awareness and likeability, and consequently brand purchase. Each proposes an ordered construction of the effects of marketing and implies that marketing effects occur over time, transitioning through cognitive, affective, and behavioral stages. Recent studies have tested these hypothesized associations and found both direct and indirect associations, indicating intermediate pathways of effects (16). For example, recall of food marketing on video-game live streaming platforms was associated with purchase and consumption of marketed foods, and this relationship was mediated by food attitudes (44). The effect of marketing on diet and weight outcomes is of principal importance for population health; however, intermediary effects on cognitive and affective outcomes are useful indicators of marketing impact that can affect downstream behavioral responses of food purchase and consumption.

While these frameworks characterize many outcomes that are of interest for investigating the impact of digital food marketing on children’s health, the pathways of marketing impact are likely more complex. Food marketing exposure also cues immediate behavioral responses, manifested in increased choice of an unfamiliar brand immediately after marketing exposure (118). Food cues,



**Figure 2**

Reactivity to embedded food cues in advertising model (REFCAM), whereby food marketing is hypothesized to induce physiological and psychological processes that influence immediate consumption and future susceptibility to food promotion. Figure adapted with permission from Folkvord et al. (48).

including those delivered through marketing, lead to conditioned appetitive responses, including cravings and consumption (12). Feedback loops also exist between outcomes along the hierarchy, such that consumption experiences of a food brand (say, at a celebration) influence brand affect. Further, marketing effects apply to both food products and brands, such that exposure to marketing for a specific brand will influence consumption of foods generally (88). The reactivity to embedded food cues in advertising model (see **Figure 2**) integrates these complexities (48).

This model, and others, propose that the less children cognitively process marketing messages, instead relying on peripheral processing of food cues, the stronger the effect of the marketing. This has been supported by experimental research, whereby the effects of marketing on food consumption were larger when participants were distracted and therefore not cognitively attending to the marketing (146). Cognitive processing of digital media marketing is hindered by the integration of food cues into media content (e.g., in games, in newsfeeds, and in content shared by online communities) and the tendency for media multitasking, affecting cognition (10).

### 3.2. Evidence of Digital Food Marketing Impacts

In recent years, some studies have explored the impact of digital food marketing on the behavioral outcomes included within the above conceptual frameworks. For proximal effects, playing food-branded digital advergaming has been demonstrated to result in significantly more positive brand attitudes in Belgian children ( $N = 940$ ) than watching television advertising or having no advertising exposure (86). In a qualitative study, young people ( $N = 209$ ) in Uruguay acknowledged the impact of digital food marketing on their awareness and desire for promoted products (3). Food marketing has also been linked to broader sociocultural impacts that underpin food behaviors, such as dietary norms (26), but this is yet to be explored specifically for food marketing in digital media.



Effects of digital food marketing have also been found on food choice and preference outcomes in children. For example, in one study, advergaming had an immediate and positive impact on Portuguese children's ( $N = 104$ ) preferences for both the brand and the food product, as well as short-term snack and brand choices (1). In another study, Australian children ( $N = 156$ ) exposed to rewarded video advertising (providing free gameplay or other rewards to players in return for viewing advertising) chose the test brand significantly more often than did children who had not been exposed to branding in the game and also significantly more often than did children exposed to other displays of digital food advertising (banner advertisements and the brand embedded as a game piece) (118).

The impact of digital food marketing on purchase and purchase-related outcomes has also been demonstrated. For example, pester intent (i.e., the intention to make a purchase request to parents) was significantly greater in Belgian children exposed to a food-based digital advergaming compared with those exposed to television advertising ( $N = 940$ ) (86). Similarly, digital food marketing was positively associated with Australian adolescents ( $N = 12,188$ ) having made a purchase request for an advertised product (112). A further study with both adolescent and adult participants in the United States ( $N = 621$ ) found that 8% of the sample reported purchasing a product after seeing the brand advertised on a video-game live streaming platform (97).

Moreover, digital food marketing exposure has been shown to affect food consumption in young people. Two randomized controlled trials reported significant effects of social media influencer marketing of foods [via Instagram ( $N = 176$ ) and YouTube ( $N = 151$ )] on increased food intake in UK children (32, 34). Importantly, experimental research from Australia has shown that children ( $N = 160$ ) do not compensate for this additional intake in response to food marketing exposure (including via digital media), suggesting that food marketing contributes to sustained energy imbalance that would, over time, lead to weight gain (88).

Systematic reviews and meta-analyses have consolidated the findings from this small but growing body of evidence of digital food marketing effects. For example, a series of meta-analyses conducted to inform new WHO global guidelines on food marketing restrictions found that food marketing exposure (across multiple media) was associated with significant increases in food choice, preference, and intake in children (14). Subgroup analyses showed that this effect was not moderated by marketing channel, such that digital food marketing exposure and television advertising appear similarly impactful.

### 3.3. Which Aspects of Digital Marketing are Most Pernicious?

Given the diversity of digital food marketing and the visual and dynamic complexity afforded to marketers through digital technology, it is relevant for researchers and policymakers to consider the extent to which the impact of these marketing forms on food behaviors may differ according to format and the creative components employed.

**3.3.1. Impact of different types of digital marketing.** Other systematic reviews and meta-analyses have demonstrated significant effects of exposure to digital food marketing through various different formats, including online advergaming (49), social media and advergaming (81), and digital game-based and social media influencer marketing (45), on children's food intake. The pooled effect sizes from these quantitative syntheses of digital food marketing have tended to fall consistently in the small-to-moderate range (14, 45, 49), suggestive of a similar level of impact across the marketing formats studied (at least for an immediate food intake outcome in children). This similarity of effect is expected given that most of these reviews pool data on the effects of marketing in online gaming, on which much of the evidence on the impacts of digital marketing is based.



Researchers have also sought to understand the persuasive power of marketing delivered via specific digital platforms. For example, the presence of features common to the Instagram platform resulted in adolescents rating food ads more positively (20), the visual characteristics of product offerings (i.e., featuring Instagrammable foods) appears critical to engagement with social media food marketing (95), and this engagement, in turn, appears important to the impact on dietary choices (6).

However, mechanistic understanding of these effects is limited. Studies have sought to address this by using functional magnetic resonance imaging to capture neurological responses to food marketing exposure in children and adults. Activations have most consistently been identified in areas relating to visual processing, attention, sensorimotor activity, and emotional processing (13). In a US study, children's ( $N = 115$ ) neural responses to marketing varied depending on the marketing medium shown. Regions of the brain associated with reward showed increased activation with dynamic video advertising rather than with static advertising images (145). Dynamic marketing is common in digital media, including on video sharing and streaming platforms and online gaming. Static advertising is typical of paid online media, including banner advertising and sponsored posts on social media.

**3.3.2. Impact of different elements of digital marketing.** A systematic review of the evidence on the impacts of digital media marketing for unhealthy commodities, including unhealthy foods, alcohol, and tobacco, on young people found variations in the effect of marketing on children's use and attitudes toward these products depending on the way that this marketing was delivered (25). Earned media was found to exert a potentially greater impact than marketing on paid or company-owned media. In one experimental study, US participants' ( $N = 413$ ) attitudes toward, and intentions to engage with, alcohol marketing through earned media on Facebook was associated with intentions to consume alcohol (2). For online posts that showed higher peer engagement (likes/shares), participants were more likely to intend to share and to use the product. Conversely, attitudes toward paid alcohol advertising online were not linked to alcohol intentions (2). Quantitative surveys in Australia ( $N = 283$  and  $301$ ) (60, 69) and India ( $N = 330$ ) (60) have found that young people's engagement with alcohol brands on social media was associated with alcohol intake and problematic drinking behaviors. In qualitative studies captured by the earlier review (25), young people were skeptical of paid advertising, including brand-sponsored social media posts. On the contrary, they did not perceive brand content shared by their peers to be marketing.

There are multiple possible explanations for why earned media marketing content appears to have an increased impact on children compared with other forms of digital marketing. As it is shared through online communities and peer networks, it leverages peer and social influences on young people's attitudes and behaviors (61). During adolescence, in particular, young people experience heightened peer pressure, as they form a personal identity separate from their parents. Marketing can contribute to identity formation and socialization by conferring social norms and expectations (51). Further, as earned media is not perceived to be marketing and is integrated into online content, children likely process these commercial messages with limited cognitive elaboration (48).

**3.3.3. Marketing embedded in entertainment content.** As noted earlier (Section 2.6), it has been suggested that food marketing that cannot be readily recognized as such is more impactful, as cognitive defenses are not activated to resist the promotional appeals (61). Food marketing in digital media is often disguised as, or embedded in, other content such as entertainment content, influencer posts or videos, and gaming (63). Food brands on TikTok actively encourage young people to embed brand and product imagery in their own social media content to further propagate their messages and amplify the brand profile (23).

**3.3.4. The power of brand building.** Branding refers to a unique name or symbol (logo) that identifies a product or company and distinguishes it from competitors. A brand is an anchor to which beliefs about brand attributes and users can be attached (31). These beliefs about, or the symbolic meaning of, brands are curated through marketing campaigns, which aim to develop positive brand associations and strong brand affinity or attachments (61, 111). Marketing portrays food brands as cool, fun, and attractive; these characteristics are reinforced through peer-to-peer communication and influencer endorsements on social media (63). In a survey with Australian children ( $N = 282$ ), most agreed that their favorite food and drink brands made them feel good, were popular among their peers, and were “just right for a person like them” (73, p. 7). In another Australian study, children ( $N = 48$ ) displayed autonomic physiological arousal (measured through skin conductance responses) to their favorite food and beverage brands (117). Arousal was higher when the brand, rather than the unpackaged product, was shown.

**3.3.5. The role of emotional persuasion in digital food marketing.** More contemporary theoretical frameworks of food marketing effects increasingly recognize that food marketing content is not typically processed via a conscious rational route; rather, the key to persuasion appears to lie in the targeting of emotion (63). Neuroimaging data, showing consistent neural activation to food marketing exposure in regions associated with emotional processing, support this explanation (13). Notably, in a study of more than 800 advertising campaigns, emotional advertising was found to be the most effective (11).

Emotional appeals are commonplace in digital food marketing to young people, including themes of fun, social connection, and family love (131), and it is often implied that there will be emotional benefits to the consumer resulting from the consumption of promoted products (63). Indeed, the use of creative methods to activate implicit emotional persuasion is fundamental to the characterization of digital food marketing (137). Food marketers can identify the specific emotions of individuals using a number of methods, including via motion sensors in game consoles, analysis of keywords in social media posts, and even keystroke patterns, and use this information to effectively target consumers in moments of vulnerability (137).

## 4. KEY CHALLENGES AND PRIORITIES IN DIGITAL FOOD MARKETING RESEARCH

### 4.1. Digital Food Marketing Research Challenges

Due to the complexity of the digital food marketing ecosystem, it poses unique challenges for researchers who seek to explore the impact of digital food marketing on food behaviors in children.

**4.1.1. Ethical considerations for researchers.** Understanding digital food marketing impacts often necessitates capturing data on children’s digital media use and the content they have viewed, specifically from the devices they habitually use to go online, to relate this to observed behaviors. For researchers, there are substantial ethical and privacy considerations (alongside the methodological challenges) inherent in doing so. These are discussed in depth elsewhere (125), but key points (often primarily relevant to studies including participants from the European Union where general data protection regulations apply, but also indicative of global good practice) include the lawfulness of data processing (including informed consent procedures), distinguishing between private and public data, acquisition of sensitive information, safeguarding, data storage, and data sharing. These aspects may place particular constraints on research into the behavioral impacts of adolescents’ digital food marketing exposure, as their engagement scope on social media is typically much broader and more diverse than that of younger children (91).



**4.1.2. Conducting research in low- and middle-income countries, and the balance of Global North and Global South countries.**

It is well documented that most studies on the digital marketing of unhealthy foods originate from Global North countries (134, 142). A systematic scoping review exploring the external and personal domains of food environment research in LMICs noted the paucity of evidence from high-quality studies, as indicated by only 22 included studies from South American countries primarily, followed by Africa (128). This lack of data may, in part, reflect specific challenges. One such challenge is the LMIC phenomenon where there is a monopoly of one particular platform, which shapes internet infrastructure in “the context of low literacy levels, low levels of computer/information technology use, and poor regulatory oversight” (96, p. 170), as observed in Myanmar with Facebook Zero (96). This warrants research attention.

However, there are some promising recent developments including in Mexico where researchers have quantified children’s and adolescents’ ( $N = 347$ ) exposure to digital food and beverage marketing during recreational internet use (87), and another group reported findings from a cross-sectional survey showing significant associations between screen time (including gaming and recreational computer use) and unhealthy diets in children ( $N = 874$ ) (119). This method has also been used in Asia. In a recent public dissemination (S. Bunluesin, personal communication), the WHO Regional Office for South-East Asia presented findings from a multicountry screen capture study across Bangladesh, Indonesia, Nepal, and Thailand. There are also emerging individual studies from the LMICs that are exploring teenage engagement in digital media marketing campaigns through influencers, celebrities, and immersive participation (83). In Nigeria and Ghana, where the consumption of highly processed foods is a sign of higher social status, aspirational themes combined with celebrity promoters is a prominent marketing strategy (83). In Brazil, evaluation of brands on a single platform (Facebook) confirmed extensive marketing of ultraprocessed foods with companies employing diverse marketing strategies that included photos, user conversations, presence of brand elements, and links with engagement prominently through videos, celebrities, and promotions (66). However, there remains a notable lack of evidence on the impact of digital food marketing on the food behaviors of children in LMICs and the Global South.

Recommendations aligned to food environment research in LMICs according to Turner et al.’s (128) conceptual framework are also applicable to researching digital marketing. These are set out in **Table 2**.

**4.1.3. Exploring inequalities in digital food marketing impact.** A 2021 systematic review of studies ( $N = 19$ ) on children’s settings, though restricted to broadcast media and outdoor billboards, revealed that children from ethnic minority and socioeconomically disadvantaged

**Table 2 Digital marketing research priorities and recommendations**

| Priority | Recommendation   |
|----------|--|
| 1        | Research in low- and middle-income country (LMIC) settings should be a priority given their pressing public health nutrition challenges                          |
| 2        | Research should harmonize theoretical concepts with empirical research   |
| 3        | Research needs to address the double burden of malnutrition, including undernutrition, overweight, obesity, and noncommunicable diseases                         |
| 4        | The development, testing, and validation of standardized instruments and metrics should be considered critical across diverse settings in LMICs                  |
| 5        | The implementation of mixed methods designs to provide comprehensive assessments of external and personal food environment domains and dimensions is recommended |



backgrounds are indeed disproportionately exposed to unhealthy food advertising, but differences in behavioral response by these characteristics have not been consistently identified (5).

There is clear cause for concern in how digital food marketing may extend socioeconomic inequalities further. In the context of political news, information inequalities occur when social media platforms as stakeholders tweak algorithmic systems with feedback loops connecting all behavioral signals to future content exposure, reproducing inequalities over time, and amplifying unequal access to news (126). This scenario is likely replicated regarding health inequalities perpetrated through digital media food marketing (137). However, research on this issue is nascent and needs to adopt a systems approach to understanding determinants in the underlying mechanisms between socioeconomic position and exposures, living conditions, and individual-level factors (39).

**4.1.4. Single platform studies in digital media.** There are valid empirical questions around the contribution of individual platforms or techniques to overall effects. This may also have policy, as well as theoretical, relevance in terms of indicating which aspects of the digital food marketing ecosystem should be prioritized for restrictive action while we continue to progress toward comprehensive policies. To date, evidence is largely limited to studies where exposure to food marketing on a single platform [e.g., Instagram (34), YouTube (32)] is manipulated before the behavioral outcome (e.g., food intake) is measured. Survey studies, in contrast, often consider exposure across more than one digital platform, for example, both YouTube and Twitch (97), but do not allow for causal inference due to the cross-sectional nature of the data. Recent studies using a more participatory approach (43, 102) to explore exposures across multiple digital platforms may provide a foundational template for other researchers to build on, potentially with the inclusion of behavioral outcome measures [e.g., using ecological momentary assessment, as has been piloted in a study of attitudes toward tobacco advertising (104)].

**4.1.5. Considering children's digital journeys and multiple touch points of brand exposure and engagement.** Earlier sections of this review describe parts of the progressive expansion of children's digital media activities and experiences over time, sometimes referred to as their digital journey. As children grow up, they naturally start to explore more of the digital world (as they do the physical one), develop interests in different content and experiences, and use internet connectivity in different ways (e.g., toward greater social connection and more mature content themes). This has clear implications for researchers seeking to understand how their online exposures influence their food behaviors. The volume and nature of food marketing that a young child may experience when using a parent's digital device to play simple online games for discrete limited periods would logically be expected to be markedly different from that of an adolescent who is online from morning until night on their own mobile digital device that is used for multiple functions including social media, retail purchases, and food ordering. Consistent with this, studies assessing exposure to digital food marketing have observed greater levels in adolescents compared with younger children (100).

In parallel, there is a need for researchers to consider children's multiple touch points of brand exposure and engagement across periods of digital connectivity. A report that maps out a day in the life of an android phone (110) provides researchers with useful insight into how this might be reflected upon in the design of research studies to investigate the behavioral impact of digital food marketing exposure. Using a smartphone that had been reset to factory settings and a new user profile (i.e., with no preexisting digital footprint), the researchers measured the collection of data by Google throughout the course of the day. In so doing, they describe an individual listening to music via a digital platform while getting ready in the morning, reading online content while traveling from home to work (or school), using an online app when purchasing foods and drinks during the day, searching for products and services online, and watching videos on YouTube in



the evening. This mapping poses multiple questions for researchers in the field of digital food marketing impact, including (a) what is the individual, and combined, effect of each of these touch points of brand exposure on food-related decision-making; (b) how does this vary both between and within individuals, and over time; and (c) what are the underpinning mechanisms?

#### 4.2. Research Designs and Methods for Understanding Food Marketing Impact

An earlier review of methodologies for assessing the impact of food marketing on children found that most studies had focused on exposure to television advertising, product packaging, and advergames and assessed the effect of marketing on food attitudes, choices, and consumption outcomes (116). Studies on food choices and intakes typically assess acute, short-term effects of food marketing on immediate behaviors. These studies have mostly applied experimental designs, whereby participants were randomized to a food or nonfood marketing exposure condition and, either during or after the marketing exposure, were asked to select a food from a choice set or to consume foods ad libitum. Food intake is then measured to give grams or energy units consumed. A small number of experimental studies have also assessed the impact of food marketing exposures on children's diets, extending the study period to capture food intake at later meals (88). Because of their design homogeneity, meta-analyses of such experimental studies have been possible (14, 45).

Other observational studies have sought to assess the impact of marketing on habitual food choices, intakes, and attitudes. These studies have mostly used cross-sectional surveys to identify associations between reported food marketing exposures and diet-related outcomes (44, 74). While these studies cannot provide evidence of a casual association, nor the direction of effect between the exposure and outcomes, they can contribute evidence of causality when a dose response is found (89). Longitudinal studies have prospectively investigated associations between children's television food advertising (101) and digital marketing (115) exposures and dietary behaviors and/or weight outcomes. Longitudinal study designs eliminate the possibility of reverse causality, and analyses can control for confounding variables that may influence marketing exposures and children's diets.

As discussed in Section 4.1, almost all studies assessing the impact of food marketing on children have been conducted in high-income countries (14). The small number of studies conducted in LMICs have employed cross-sectional surveys (e.g., 82) or experimental designs (e.g., 58). It would be worthwhile to establish a mechanism to share protocols and research instruments to facilitate capacity building, knowledge generation, and more harmonious collection and reporting of outcomes for improved pooling of data. Such mechanisms are currently available for sharing research methodologies for studies monitoring children's exposure to food marketing, such as through INFORMAS. A similar approach could be pursued to support research on food marketing impacts. One such project is the Canada-led International Food Policy Study, which is designed to examine the impact of various food policies, including those related to food marketing, in five different countries (68). The project includes both youth and adult surveys and is conducted annually in Canada, the United States, Mexico, the United Kingdom, and Australia, with questions on diet-related knowledge, attitudes, and behaviors and their experience with a range of variables from the food environment including food marketing. Questions on food marketing exposure and impacts include children's preferences for frequently advertised brands and, for adults, the frequency of their child's/children's purchase requests for, and parent's purchases of, marketed foods.

#### 4.3. Digital Food Marketing Research Priorities for the Future

The evolution of the digital food marketing environment is evident when reflecting on the evolving foci of published studies of its prevalence and persuasive power (outlined in Section 2.5) and

impact on children's food behaviors and diet (outlined in Section 3.2). The earliest studies explored food brand websites and online advergames, and the latest studies typically examine live stream gaming and more complex forms of interactive media content. Given that academic research often moves at a slower pace than technological development, researchers need to try, where possible, to anticipate future directions in digital food marketing and direct their research activities accordingly. For example, in parallel with growing evidence of food marketing reaching young people through an infiltration of sports in the physical world (22), food brands are also now seeking to capitalize on the huge popularity of electronic sports (e-sports), a form of multiplayer video-game competition, and gaming (109), as noted in Section 2.5. In the United Kingdom, more than 70% of 12- to 15-year-olds report playing video games online and watching live streams (129) so these platforms appear to give marketers unparalleled access to the key adolescent demographic [potential lifelong consumers, a hugely profitable asset (63)]. Growth in food marketing investment in e-sports and gaming has been observed from video-game publishers, media outlets, and online streaming companies (56). The marketing primarily promotes energy drinks, snacks, and food delivery firms and apps (42), often selling the notions of augmented gaming performance, improved stamina, and convenience (56). Research on the impact of these forms of marketing is in its relative infancy (45) but should be prioritized in the coming years.

Food delivery apps (FDAs) are an online platform for the ordering of foods and drinks, often including alcohol, for delivery. FDAs are now the most common form of food delivery in Europe, with usage and popularity having increased substantially during the COVID-19 pandemic. Young adults and adolescents are thought to be the heaviest users (141). This is a concern, given that foods prepared away from home are often of poor nutritional quality and have large portion sizes, and FDAs encourage prioritization of convenience over health. Those at socioeconomic disadvantage may have greater exposure to unhealthy food options, adding to inequalities (9). Few studies have examined the extent and nature of this marketing in FDAs, but emerging findings suggest the presence of multiple strategies (including salient imagery and price promotions), particularly for unhealthy items (67). There is also tentative evidence that marketing for package deals or loyalty discount rewards can encourage larger orders and potentially overconsumption (141). FDAs, therefore, should also be identified as another priority area for research, particularly as these are another means for food companies to collect data on youth.

The digital ecosystem continues to develop rapidly, with the current structure of browsers and social media platforms thought by some to be shifting to a new iteration whereby we will use and interact with digital technologies within an immersive virtual environment—the so-called metaverse (143). The specifics of this new ecosystem are not yet fully realized, but it appears likely that virtual worlds and interactive technologies that are already in widespread use via games such as Roblox and Fortnite (hugely popular with children) will increasingly become part of a mainstream synchronous digital experience that includes augmented reality, virtual reality, mixed reality, and avatars (configurable digital bodies) (41). This is likely to have substantial implications for how we experience food marketing and our levels of exposure, given its persuasive power and impact on diet. Celebrities, individuals, and businesses are already beginning to use the metaverse as a brand extension (4, 70), and Coca-Cola made history in 2022 when it launched a gaming-inspired version of its drink in the metaverse prior to it being physically available in stores (64). Researchers should endeavor to monitor the evolution of digital food marketing via the metaverse and seek to quantify the impact on children's dietary outcomes. It may be that some of the very same technologies being used to deliver marketing may also have utility as a tool for measuring its impact—for example, virtual reality approaches show promise for application in eating behavior research (136), including in children (30, 94).



The power of brand building in the context of digital food marketing was outlined in Section 3.3.4. Related to this, increasing our understanding of the impact of brand-only marketing (marketing that does not identify a specific product) should be a priority. It is expected that this marketing will become increasingly prominent as countries move to enact restrictive policies that classify what is restricted at a product level using nutrient profiling (15), a method not currently adapted to allow application to brands themselves. Previous studies have shown high awareness and knowledge of unhealthy food brands even in young children ( $N = 172$ , 3- to 5-year-olds) (124), and brand awareness was positively linked with energy intake in a pilot study with children ( $N = 43$ ) (50). Neural activity in children has been seen in response to exposure to food brand imagery (13), and the presence of branding influences children's ( $N = 63$ ) taste perceptions. However, there is, to date, a lack of research into the impact of brand-only marketing on eating outcomes in children.

As noted previously (Section 3.2), food marketing has also been implicated as an influence over sociocultural determinants of dietary behaviors such as food culture, food norms, food values, and food practices and habits (26). Some studies have explored how food marketing may affect social consensus around foods (i.e., shared understanding of acceptable and/or desirable foods and behaviors), for example, through a social learning effect pathway. One study found that parents' propensity to feed their children fast food was significantly related to a combination of the potency of their belief about the social acceptability of this behavior and its assumed prevalence within their social networks (59). However, this is currently underexplored with respect to children (compared with adults), and data on these outcomes as related to digital food marketing specifically are lacking.

It is critical for researchers to measure the impact of digital food marketing by different population subgroups. Only two studies (28, 78) (out of 25 studies included in a previously cited systematic review on this topic) considered online forms of food marketing exposure, and this was alongside other media such as television in both cases. A recent evidence synthesis has identified a lack of studies of food marketing impact with data segregated by key equity characteristics (14) [i.e., those included within the PROGRESS-Plus framework (36)]. Further, it has been noted that despite adolescents forming a key demographic for marketers and potentially having particular vulnerability to food marketing exposure (63), research studies examining adolescents exclusively are relatively rare [composing just 18% of the youth-focused literature (127)]. There is also some evidence of gender differences in marketing exposure and responsivity, specifically that boys may experience more intensive food marketing exposure via male-dominated content that affected their preferences to a greater extent than it did for girls (27). Therefore, renewed efforts should be made to ensure that socially stratifying factors are considered in the conduct and reporting of digital food marketing impact studies so that contributions to inequities in health outcomes can be better understood.

## 5. THE ADVOCACY AND PUBLIC HEALTH POLICY IMPLICATIONS OF DIGITAL FOOD MARKETING RESEARCH

### 5.1. Key Considerations for Advocates and Public Health Policy Progress

Prevention of obesity in childhood is a public health priority internationally, which also lays the groundwork for preventing chronic disease development. A comprehensive systems approach to regulate unhealthy food marketing (128) is required with commitments from government, food industry, and digital platform stakeholders to uphold the rights of children to protect them from exposure to the marketing of high in fat, salt, and/or sugar (HFSS) food products through digital media (130). International health agencies have, to date, played a leading role in promoting



best practices to reduce children’s exposure to food marketing, including in digital spaces (77). Consistent with this, in 2023 the WHO published new global guidelines for the development and implementation of restrictive food marketing policies applicable to all media and settings, building on the 2010 recommendations (138) by explicitly promoting a mandatory approach (144).

Government responsibility in shaping mandatory regulation of digital platforms is clearly very complex given the manifold support functions provided for e-commerce such as search engine optimization, search engine marketing, content marketing, influencer marketing, content automation, campaign marketing, social media marketing, social media optimization, games, and so on, which afford engagement and exposure at many levels to attract customers. But underlying these functions, it is a matter of public interest to understand how digital platforms extract value through the combined processes of datafication, commodification, and selection (135) and how comprehensive legislation needs to be to adequately restrict children’s exposure to unhealthy food marketing (15).

But how do advocates drive government stakeholders to implement mandatory policy interventions to regulate digital marketing when platforms have acquired scalability and indispensability to function as vital infrastructures essential to multiple social and economic sectors in many countries, particularly the LMICs (96)? It is observed that Google, Facebook, and Microsoft have investments in building and maintaining data centers, enhancing telecommunication networks, and even providing internet services in these countries (96). Such investments become barriers to any intended advocacy for mandatory regulation.

Boyland et al. (18) recommend advocacy actions at several levels to address the public health challenge from unhealthy digital food marketing (see **Table 3**).

## 5.2. Key Challenges for Digital Food Marketing Regulations

Few countries around the world have legal measures in place to protect children from the digital marketing of unhealthy foods, with most relying on industry-led codes. These codes are written, monitored, and enforced by the food or tech industries, which profit enormously from this marketing, posing a clear conflict of interest. In 2020, tech giant Google voluntarily implemented restrictions on the advertising of HFSS foods and nonalcoholic beverages to children under the age of 18 years in the United Kingdom and European Union on the Google Display Network (GDN) and YouTube. While the Google nutrient profile model has been found to capture the most unhealthful foods (if implemented as intended) (40), it does not limit unhealthy food marketing across all online sources and does not protect children from other sources of exposure (i.e., marketing via non-GDN platforms). It is also curious that Google announced and implemented their self-regulatory measures around the time the UK government started consulting on their

**Table 3** Advocacy actions to address digital food marketing

| Sector      | Action   |
|-------------|--|
| Individual  | Raise awareness of the issue among stakeholders including consumers (young people, parents), health campaigners and experts, and policymakers to encourage parental intervention and political will for action                               |
| Societal    | Encourage scientific societies dedicated to child health to collaborate to achieve meaningful policy progress to restrict children’s exposure to marketing for unhealthy foods and beverages online  |
| Commercial  | Promote greater transparency from food and beverage industries and marketers with respect to the data they hold on digital food marketing prevalence and impact, as well as facilitation of appropriate access for researchers to those data |
| Legislative | Call on governments to introduce or strengthen policies to restrict the exposure of young people to the digital marketing of unhealthy foods and beverages   |



proposal to ban unhealthy food marketing through online media. The development of voluntary self-regulatory codes is a well-known tactic within the corporate playbook for delaying or avoiding a government-led legal response (79). It is not surprising that global evidence reveals that industry-led codes to regulate unhealthy food marketing are less effective than government-led regulations (15).

No country has implemented a strong legal response to restrict digital food marketing to protect children. Chile's 2016 food labeling and advertising law banned all unhealthy food marketing considered to be directed to or intended for children under the age of 14 years, including via the Internet. Canada is also proposing to restrict less healthy products primarily directed at children from being advertised in all digital spaces including websites, social media, other applications, email, video and audio streaming, online video games, and virtual reality platforms, though specifics (including an implementation timeline) have yet to be shared (57). This focus only on marketing content that is directed to children is problematic, as online environments are often shared spaces between children and adults, and social media age verifications can be easily circumvented (113). Recognizing these complexities with restricting unhealthy food marketing that is either directed to children or published online at certain times (e.g., during hours when children most use the Internet), the UK government recently enacted a law to restrict all paid for (monetary or nonmonetary) marketing of unhealthy foods online. However, at the time of writing, implementation has been delayed until 2025.

As more governments consider legal measures to protect children from the online marketing of unhealthy foods, it is prudent to reflect on the challenges for policy development. First, the porous borders of the online world can make it difficult for countries to control marketing that originates from outside their national boundaries. Governments can regulate the actions of actors outside of their borders if the company is providing services or products inside their borders, but the real challenge is with enforcing those laws with broad jurisdictional reach covering large powerful actors based in other countries. There are other ways governments can enforce their laws extraterritorially through enforcement cooperation, where governments work together, either regionally or globally.

The inclusion of brand marketing within the regulatory framework is another often-cited challenge (113, 114). Ensuring that brands that are synonymous with unhealthy products are included in a regulatory response is essential to adequately capture the extent of unhealthy food marketing—this will require a way of classifying unhealthy brands. Governments may also consider that regulating digital marketing may be outside of the jurisdictional scope of ministries of health. While there is a need for coordinated laws and government agencies, a ministry of health can have confidence in leading the development of such regulation, potentially in partnership with government agencies who are responsible for digital regulation more broadly.

The lack of existing efficient monitoring systems to evaluate policy implementation and detect breaches to law has been widely cited as a key barrier to policy development (132). Manual methods of data collection are time consuming and costly. Innovative methods for monitoring the digital marketing of unhealthy foods are emerging (71). Screen capture technologies can record online activities of children (72), and web crawler tools can collate data on the online activities of food companies (46). Deep learning-enabled analysis systems can then analyze the data by automatically detecting and classifying unhealthy food marketing within the video or image files (92). As the capabilities of these tools and technologies develop, such methods will become cheaper and more efficient to deploy.

Gold-standard policy design for regulating digital food marketing would include all paid marketing (monetary and nonmonetary) including influencer marketing, unpaid marketing (e.g., food companies encouraging users to create branded content), and food companies' sharing of

user-generated content for marketing purposes. Liability would be placed primarily on the advertiser and platforms, with the potential to also hold intermediaries in the marketing chain liable. Monitoring and enforcement mechanisms would be designed early with roles, responsibilities, and resources defined in the law. It is also essential that any legal measures are designed for a rapidly evolving digital ecosystem. This will require broad, nonexhaustive definitions that as far as possible can ensure that all new forms of digital marketing and changes to the digital ecosystem are captured.

All countries can face the difficult decision of how to design a legal response to unhealthy food and beverage marketing that doesn't impermissibly infringe on other fundamental protected rights—particularly the right of freedom of expression and the right to property, including intellectual property (53). Ultimately, no right is absolute, especially commercial rights (140). All rights can be limited if it can be shown that there is a legitimate public need, for example, a legitimate public health objective to be achieved, and the measure is proportionate [i.e., adequate to reach the intended objective, not more trade restrictive than necessary, and not discriminatory, in terms of the origin of the products or marketing concerned (55)].

Ultimately, regulating digital food marketing requires bold political leadership. It requires governments to rise above the formidable opposing force of the food and tech industries and to take measures to protect children from the digital marketing of unhealthy foods. The research community and civil society can support policy development by providing technical skills and resources, particularly within LMICs. Critically, it is then necessary for these policies to be independently evaluated with learnings and outcomes shared. Regulating the digital marketing of unhealthy food is technically feasible, but more work is needed to increase the political feasibility of the legal response.

## 6. CONCLUSIONS

This review provides a narrative synthesis and overview of the body of global evidence of children's experience of digital food marketing, the impact of that marketing on their food behaviors, the development of research approaches and priorities that can help to address gaps in understanding, and how such understanding may be translated into meaningful public health policy action to protect children's health. The evidence is unequivocal that children are avid users of digital media, which is saturated with unhealthy food marketing, and that this marketing is increasingly embedded in content, is interactive, and seeks to persuade children at an emotional level. Cross-sectional and experimental studies have demonstrated that exposure to digital food marketing has significant detrimental impacts on food behaviors (such as choice and intake) and their antecedents (including attitudes and preferences). There is some evidence that different exposures can have differential impacts, for example, earned media (with implicit or explicit peer endorsement) may be more persuasive. Marketing impact may also be dependent upon the extent of engagement the child has with the brand and how integrated the marketing message is within entertainment content. These findings are consistent with, and challenge, existing conceptual frameworks and theories used to guide food marketing research to date. The embedding of food marketing and the role of emotional persuasion illustrate the utility of newer models that account for such complexity, relative to older models that may have overemphasized the importance of rational cognitive processing. There are unique components to digital food marketing that set it apart from more traditional marketing means (e.g., television commercials). This may require the development of conceptual frameworks that better account for the increasingly innovative delivery mechanisms of digital food marketing delivery facilitated by synchronous exposure platforms (e.g., video-game live streaming) and more immersive digital experiences (e.g., the metaverse). There is evidence of



methodological innovation from researchers through the use of virtual reality and similar technology, although technological development exhibited by commercial operators (facilitated by digital data and artificial intelligence) also continues apace. Research approaches that seek to capture the impact of digital food marketing on children should seek to generate the best-quality evidence but also to ensure that there are robust and feasible low-resource options to support evidence generation (and policy progress) in LMICs. The legislative challenges for policymakers seeking to protect children from the demonstrated harms of digital food marketing are recognized and acknowledged, but they do not justify inertia when children's health is at stake. Policy progress is possible, with sufficient political leadership, will, and international cooperation as a foundation for action. The technological capabilities exist to effect meaningful change in the digital food marketing ecosystem, and there is a clear rationale for doing so. This review outlines the strength of the extant evidence base of digital food marketing impact, supports the generation of further evidence to address gaps in understanding, and supports public health policy action to reduce exposure to digital food marketing for the improvement of dietary, and overall, health in children.

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