

Conceptualizing the Digital Food Environment: A Framework

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Abstract

Food environments are important determinants of food choice and consumption and, consequently, drivers of global health and nutrition challenges such as obesity and noncommunicable diseases. These challenges are intensified by the ubiquitous presence of digital technology, which affects food practices. The goal of this study was to develop a middle-range theory for understanding the digital food environment in late modernity. We conducted a critical realist grounded theory study based on elicited data (from semi-structured interviews and observation of digital platforms, tools, and services) and extant data (from interdisciplinary scientific literature). We conceptualize the digital food environment as an augmented space where social and material food practices take place, mediated, enhanced, enabled, or replaced by digital technology, influencing food consumption and impacting nutrition, health, and equity. Our proposed model represents the digital food environment as a socially co-produced space, where the interplay between structure and agency shapes food practices, driven by late modern processes such as digitalization, informationalism, individualization, commercialization, and exposure amplification. The digital food environment has a governance model where technology companies, digital content creators, and non-human agents are key actors, increasing the complexity of food practices and power asymmetries that affect food choice, consumption patterns, and health narratives. Policies to promote healthy food environments must consider their increasingly digitalized nature.

Keywords

artificial intelligence; digitalization; food environment; healthy diets; late modernity; social media; structure and agency

1. Introduction

Healthy diets are essential for maintaining good health, preventing malnutrition in all its forms, and reducing the risk of several noncommunicable diseases (WHO, 2020). Yet globally, unhealthy diets contribute to high morbidity, mortality, and loss of healthy life years (Afshin et al., 2019). They are also unequally distributed within and across countries, affecting the poorest groups disproportionately (Development Initiatives, 2020; FAO et al., 2024; WHO, 2023b). Disparities in food availability, accessibility, cost, and quality (Blanchard et al., 2024) highlight the importance of addressing the social determinants of health and making food systems more sustainable, resilient, and equitable to support healthy diets (Fanzo et al., 2021).

The food environment is a central concept used to understand the influences on people's access to healthy diets (Swinburn et al., 2011). Unhealthy food environments have been implicated in, for example, the obesity crisis (Hall, 2018; Pineda et al., 2024), though measuring their direct impact on health and nutrition remains a challenge (Hall, 2018; Lytle & Sokol, 2017; Penney et al., 2014). Multiple food environment frameworks have been proposed in the past three decades since Egger and Swinburn (1997) first argued for an ecological approach that considers the wider influences on individuals to better understand the obesity pandemic.

1.1. Current Approaches to the Conceptualization of the Food Environment

There are several approaches to understanding and defining the food environment. For Swinburn et al. (2013, p. 25), the food environment is "the collective physical, economic, policy and sociocultural *surroundings, opportunities and conditions* that influence people's food and beverage choices and nutritional status" (our emphasis). For Turner et al. (2018, p. 95), it is "the *interface* that mediates people's food acquisition and consumption within the wider food system" (our emphasis). Other definitions have, for instance, described the food environment as the *characteristics related to actual foods* (Herforth & Ahmed, 2015), as the *contexts* related to eating behaviours (Story et al., 2008), as the "*physical environment* that influences an individual's diet" (our emphasis; Backholer et al., 2017, p. 3), or as the "*range of food products and sources* that can be accessed" (our emphasis; Boise et al., 2023, p. 2).

Definitions converge on the idea that food environments are external to individuals and determine dietary behaviours by shaping food choice, while acknowledging the role of individual characteristics. Frameworks typically encompass one or more of the following dimensions: food availability, affordability, accessibility, price, marketing and promotion, desirability, labelling, quality, convenience, and vendor properties (Backholer et al., 2017; Fanzo et al., 2021; Global Panel on Agriculture and Food Systems for Nutrition, 2016; Raza et al., 2020; Turner et al., 2018; van Berkum et al., 2018). Many also emphasize the role of broader sociocultural, economic, and policy influences in shaping these environments (Bennett et al., 2024; Downs et al., 2020; High Level Panel of Experts on Food Security and Nutrition, 2017; Story et al., 2008; Swinburn et al., 2011, 2013). Downs et al. (2020) have highlighted sustainability in their approach, reflecting a recent shift towards integrating planetary health and sustainable diets in food environment research and action. Others such as Glanz et al. (2005), Caspi et al. (2012), and Raza et al. (2020) distinguish between different levels of the food environment, such as the local/community, the consumer/personal, and the organizational levels. More recently, a family food environment model has been proposed (Ambikapathi et al., 2024), as well as a model that distinguishes between wild and cultivated food environments (Downs et al., 2020; Zeitler et al., 2024). The concept of the food environment is sometimes used interchangeably with the concept of foodscapes (MacKendrick, 2014;

Vonthron et al., 2020), though the linkage with health and nutrition outcomes is not always present or evident in foodscape research.

Overall, research on the food environment has largely prioritized its physical dimensions (Cifuentes & Sonnino, 2024), with limited attention to the theoretical exploration of this phenomenon, though its need has been recognized (Turner et al., 2017). Recent contributions to this theoretical development include the conceptualization of food environments as assemblages, developed by Cifuentes and Sonnino (2024), highlighting their dynamic and transformational nature. From an assemblages perspective, the food environment is “a dynamic place, which comprises heterogeneous (mobile and fixed) components,” which are “assembled to serve its purpose(s)—which, so far, has narrowly been described as the availability and accessibility of desirable foods” (Cifuentes & Sonnino, 2024, p. 4). Further, Mattioni et al. (2020) proposed a sociological approach to food environments, in which the need to better integrate the sociocultural understandings of food and food practices emerges. Rather than neutral places where physical transactions with food occur (i.e., food purchase), they argue that retail outlets are cultural intermediaries that transmit notions of food that have implications for diets (e.g., what counts as food, notions of healthiness), with social food practices mediating how people interact with the food environment (Mattioni et al., 2020).

Indeed, framing food practices within the food environment as social practices enables a better understanding of the dynamic relationship between the social context (structures) and people’s everyday actions (agency), providing a conceptual lens for exploring the underlying social relations that connect individuals in society and determine dietary patterns (Delormier et al., 2009). Understanding the interplay between structure and agency is essential, as food environments are not passive, static contexts, but rather continually and actively shaped by the social practices of individuals, groups, and organizations. As described by Cifuentes and Sonnino (2024), food environments are not simply the background against people’s lives. At the same time, there is overwhelming evidence that powerful structures shape nutrition, health, and equity outcomes. The commercial determinants of health, which refer to the systems, practices, and pathways through which commercial actors impact population health by influencing societal norms and values, policies, economies, and behaviours in favour of profit (Gilmore et al., 2023), illustrate the power of such social structures. Commercial actors in the food environment exert considerable influence over what diets are attainable, as evidenced by the global rise in sales and consumption of unhealthy, ultraprocessed foods (Baker et al., 2020; Monteiro et al., 2013; Moodie et al., 2021), despite evidence of their health harms (Chen et al., 2020; Lane et al., 2024; Pagliai et al., 2021).

Conceptualizing food environments as contingent, relational, and active spaces emphasizes their dynamic nature and susceptibility to transformation in the context of broader societal change, as that brought by late modernity.

1.2. Food Environment Transformations in Late Modernity

Late modernity refers to the period of societal development from the mid-20th century to the present, marked by profoundly transformative processes. One such process is globalization, which increases the interconnectedness of economies and cultures, making information and communication more central to society, fostering interdependence, and bringing distant events closer to people’s daily lives (Giddens, 1990). Late modernity is also characterized by increased reflexivity, as individuals find themselves reevaluating and

adapting their identities, beliefs, and lifestyles in response to the availability of information and rapid social change that characterizes a more fluid, “liquid” society (Archer, 2012; Bauman, 2000; Beck & Beck-Gernsheim, 2002; Giddens, 1991). This encourages a continuous process of self-identity formation and improvement, promoting individualization rather than collective societal arrangements (Beck & Beck-Gernsheim, 2002; Giddens, 1991). Underpinned by neoliberal ideology, these processes reframe health as a matter of personal responsibility, shifting the burden of ill health to individuals rather than considering the weight of the broader determinants of health and equity, thus downplaying the role of the state in supporting healthy environments (De Souza, 2011; Dutta, 2015).

Another central feature of late modernity is the extended reach of science and information through advancements in digital technology (Brossard, 2013; Castree et al., 2013). While these developments contribute to the democratization of knowledge, they also expose deep inequalities in access. The digital divide limits the ability of marginalized populations to fully participate in and benefit from the digitalization of society (Lythreath et al., 2022). Consequently, rather than universally empowering individuals, digital advancements can reinforce existing socioeconomic disparities (Crawford & Serhal, 2020). Additionally, expert knowledge is more widely available and continuously revised and scrutinized, allowing a pluralism of expertise (Giddens, 1990). This contributes to the erosion of traditional scientific authority, creating vulnerabilities such as widespread misinformation in a world where digital literacy remains a challenge (Borges do Nascimento et al., 2022; Denniss & Lindberg, 2025; Estrela et al., 2023; Smith & Magnani, 2019; Suarez-Lledo & Alvarez-Galvez, 2021; Swire-Thompson & Lazer, 2020; Tsao et al., 2021).

These late modern processes have implications for food environments. For instance, globalization has altered the profile of foods available in the food environment, in terms of quantity, type, and cost, bringing closer diets that used to be distant, thus broadening the scope of individual food choice, at least in theory (Fonte, 2021; Hawkes, 2006). Furthermore, people may reevaluate and adapt their diets having been influenced by social media content and digital marketing (Boyland et al., 2022; Hawkins et al., 2020). The ubiquity of health and nutrition misinformation is also part of this context, undermining trust in official health advice and promoting anxiety and uncertainty about diets (Diekman et al., 2023; Jackson, 2010; Nagler, 2014; Östberg, 2003; Vijaykumar et al., 2021). In short, the food environment has become a much more complex landscape to understand and conceptualize.

Digital technology is increasingly integrated into every aspect of life, with growing recognition of the digital determinants of health and equity (Chidambaram et al., 2024; Holly et al., 2025; Kickbusch & Holly, 2023; Richardson et al., 2022; Tefera et al., 2025). As digital technologies become embedded in our daily activities, they create new patterns, routines, interactions, and spatial configurations (Franklin, 2015). Digitalization affects the different dimensions of the food environment (Granheim et al., 2021), from online food retail to meal delivery smartphone apps and digital food marketing (Bennett et al., 2024; S. S. Jia et al., 2025). However, the digital dimension is often underrepresented or absent in existing food environment frameworks.

The *digital food environment* is an emergent concept in scientific literature, with initial efforts at conceptualization appearing since 2019 (Bennett et al., 2024; Cong et al., 2025; Granheim, 2019; WHO EURO, 2021a). It has been described as the “online aspects of the modern food environment” (Bennett et al., 2024, p. 2) and as “online settings through which flows of services and information that influence people’s food and nutrition choices and behaviour are directed” (WHO EURO, 2021a, p. 1). A tentative conceptual

framework was proposed by Granheim (2019), indicating digital activities, digital settings, and digital actors that comprise the digital food environment. Cong et al. (2025) developed a conceptual framework for food environments and food systems that take digital platforms into account, while De Castro and Canella (2022, p. 6) included “virtual surroundings” as part of their conceptual model on organizational food environments. Nevertheless, these conceptual models remain preliminary and insufficiently grounded in social theory, limiting their explanatory power and ability to account for the complex effects of digitalization on food environments. Thus, further theorization of the digital food environment as a social phenomenon in the context of late modernity is warranted.

Therefore, the main goal of this study was to develop a theoretical framework for understanding the digital food environment in the context of late modernity, as a step towards more theory-informed food environment studies. It acknowledges and builds upon decades of global scholarship across several fields of knowledge that have conceptualized and advanced the notion of food environment, aiming to further extend this body of work by accounting for the process of digitalization. We propose a definition and a theoretical framework for the digital food environment that is empirically grounded and informed by social theory, thus offering an ontological foundation for its continued investigation.

2. Methods

This study employed a critical realist grounded theory approach to develop a middle-range theory on the digital food environment (Kempster & Parry, 2011; Looker et al., 2021; Oliver, 2011). Given that grounded theory methodology is still underdeveloped within a critical realist framework, the study was heavily informed by other traditions, in particular, the work of Charmaz (2014) and Corbin and Strauss (2015). Middle-range theories are positioned between formal theories, which are more general, and substantive theories, which are specific and more common in grounded theory research. Unlike substantive theories, middle-range theories are not tied to a specific context or population group, but aim for broader applicability, without seeking to create an all-encompassing, unified social theory (Merton, 1968). Our goal was to develop a middle-range theory on the digital food environment as an overarching framework with potential applicability across different contexts, without claims of universality or infallibility.

In line with a grounded theory approach, data collection and analysis were conducted iteratively and concurrently over the course of the study, which took place between 2019 and 2025. Our proposed middle-range theory is grounded in the analysis of elicited and extant data. The combination of multiple sources of data is supported by the basic grounded theory premise that “all is data” (Glaser, 1998, p. 8). Having different “slices of data” (Glaser & Strauss, 1999, p. 65) contributes to a richer understanding of the phenomenon studied, allowing the creation of new codes and categories and helping to describe their properties in ways that elicited data (interviews) alone could not achieve.

Extant data were collected in the form of published research articles related to the food environment and digitalization. In the case of interdisciplinary studies, scientific literature is particularly useful as data in grounded theory, as it helps integrate insights from multiple disciplines on a given phenomenon (Paterson et al., 2001). It is also necessary when theorizing beyond substantive theories (Glaser & Strauss, 1999; Martin, 2019). Extant data were initially collected through an interdisciplinary systematic scoping review of the literature, which analysed 357 studies published between 2000 and 2019 (see Granheim et al., 2021 for

detailed methodology and results). This was supplemented by ongoing theoretical sampling of emerging academic studies and grey literature throughout the course of this study. This allowed for the existing body of knowledge regarding digitalization of food environments to constitute a core part of middle-range theory building. The scoping review also supported the development of sensitizing concepts (G. A. Bowen, 2006) that informed a semi-structured interview guide used as a starting point for the collection of elicited data.

Elicited data were collected through semi-structured interviews with young women aged 18–25 years in Norway ($n = 14$), as well as theoretically sampled secondary materials mentioned during interviews (e.g., websites, food-related smartphone apps, and social media influencer channels and their content). Young women were deemed a relevant group for exploring the influence of digitalization on food-related practices due to their high engagement with digital media and increased vulnerability to social media representations of diet and body image (Brasil et al., 2024; Dane & Bhatia, 2023; Lupton, 2017a; Statistics Norway, 2024). The intergenerational impact of nutritional status among women of reproductive age is well-established in the literature, and women continue to bear the primary responsibility for food-related tasks at home, in Nordic countries and elsewhere (S. Bowen, 2021; Stephenson et al., 2018; Storz et al., 2022). The age group of 18 to 25 years was chosen as it represents a transitional phase into adulthood, with changes in residence, employment, and social relationships, as well as increasing autonomy regarding food choices, making them more active participants in their food environment.

Young women were purposively sampled both in person and online, through acquaintance referrals, social media, emails, and leaflets distributed to youth organizations, public services, and universities. They were asked about their use of digital technology in food-related activities such as food purchase, meal planning, and seeking nutrition and health information. The elicited data from the young women informed the development of a substantive theory on the digitalization of food environments in Norway (see Granheim et al., 2025 for detailed methodology and results), which served as a foundational component in the development of the middle-range theory presented in this article.

Interviews were transcribed verbatim and coded line-by-line (Charmaz, 2014) in NVivo. Memos documented the observations from secondary elicited materials. The scoping review charting table and selected studies were used to generate additional codes. As the data gathering and coding process developed, codes were clustered into categories, which were then used to build core categories. Following the constant comparative method of grounded theory, memoing and diagramming were employed throughout the analysis to capture initial analyses, refine developing ideas, and enable comparisons and conceptual relationships, thereby supporting the progression of the analysis beyond a descriptive account towards greater theoretical abstraction (Charmaz, 2014; Corbin & Strauss, 2015). Recruitment ended when interviews no longer yielded new insights that significantly advanced the developing theory, indicating that theoretical saturation had been reached. Theoretical saturation was not fully reached for extant data, since the interdisciplinary nature of the digital food environment and the rapid technological changes constantly taking place ultimately mean that new processes and categories will continually emerge. As argued by Saunders et al. (2018), however, theoretical saturation should align with the research questions, and there should be some limit to its scope, in order to avoid stretching the study too widely and risk losing coherence and depth.

The analysis and theory-building process was underpinned by critical realism as a meta-theoretical framework, drawing on Bhaskar's (1975) transformational model of social activity (TMSA). According to the

TMSA, social life is ontologically constituted of four interrelated dimensions: social structures, human agency, social interactions between people, and material transactions. Within this framework, social structures simultaneously enable and constrain agency, while agents, through their actions and interactions, reproduce or transform those same social structures (Bhaskar, 2016). The TMSA served as an ontological lens for our analysis as we examined codes, categories, and core categories in relation to the four dimensions of the TMSA and developed a definition and theoretical model of the digital food environment that reflect this ontological understanding of social reality.

The constant comparative method of grounded theory applied in this study involved abductive/retroductive reasoning. Abduction is not an exact technique but rather an intellectual process of discovery that involves iterative interpretation and testing of explanations to reach a plausible theoretical interpretation of the empirical data (Reichertz, 2007). Following Charmaz (2014), we began by examining data inductively to develop codes and categories, which were compared and appraised in relation to each other, and, in relation to relevant social theories that address late modernity, to develop a plausible theory with strong explanatory power. Abductive reasoning overlaps with the logic of retroductive reasoning in critical realism, with Bhaskar (2016) noting only a relative distinction between the two. While abduction focuses on interpreting empirical data to generate plausible theoretical explanations, retroduction goes a step further by seeking to logically infer the underlying conditions causing the empirical observations to occur. Thus, retroduction supports the identification of what critical realists have termed generative mechanisms (Bhaskar, 1986, 2016; Buch-Hansen & Nielsen, 2020; Danermark et al., 2019). Our approach was mostly abductive, through iterative engagement with empirical data and existing theory, with the retroductive questioning of the data used sparsely. Nevertheless, retroductive reasoning supported the abstraction process necessary for developing our middle-range theory, enabling us to infer broader societal processes that act as drivers of the digital food environment in the context of late modernity. These processes can be understood as the generative mechanisms shaping the digital food environment in the form and dynamics that we observed and interpreted.

The following example illustrates how our different sources of data were integrated through abductive/retroductive reasoning during the analysis. Interviews with young women revealed a narrative of self-optimization, reflected in practices such as using smartphone apps to track diets and tailor them to personal health-related goals, alongside exposure to algorithmically personalized food-related content on social media (see Granheim et al., 2025). Individually tailored features, such as personalized price promotions and discounts, were also observed in the digital tools and platforms that they reported using and which we analysed. Additional evidence from scientific literature identified a range of strategies through which digital food marketing leverages personalization, for instance with artificial intelligence (AI) employed to optimize engagement and individual targeting. Through iterative comparison of codes across data sources, the category “personalization and tailoring to individuals” was developed. We inferred the existence of a broader underlying process, individualization, as a potential generative mechanism shaping the digital food environment and fostering the personalization and individual tailoring that we observed. To further interrogate this interpretation, we consulted relevant social theorists of late modernity and identified that some, such as Beck and Beck-Gernsheim (2002), have theorized individualization, which helped us contextualize and refine our interpretation. We then assessed whether our developing theorization accounted for the observations from elicited and extant data, and found that it provided a coherent explanatory framework, thus warranting inclusion in the final theoretical framework.

3. Findings and Discussion

3.1. Defining the Digital Food Environment

Our analysis of elicited and extant data indicated that digital technology has become profoundly embedded in food environments in late modernity, shaping their configuration and functioning. We define the digital food environment as an augmented space where social and material food practices take place, mediated, enhanced, enabled, or replaced by digital technology, influencing food consumption and impacting nutrition, health, and equity. Figure 1 presents a visual representation of this definition.

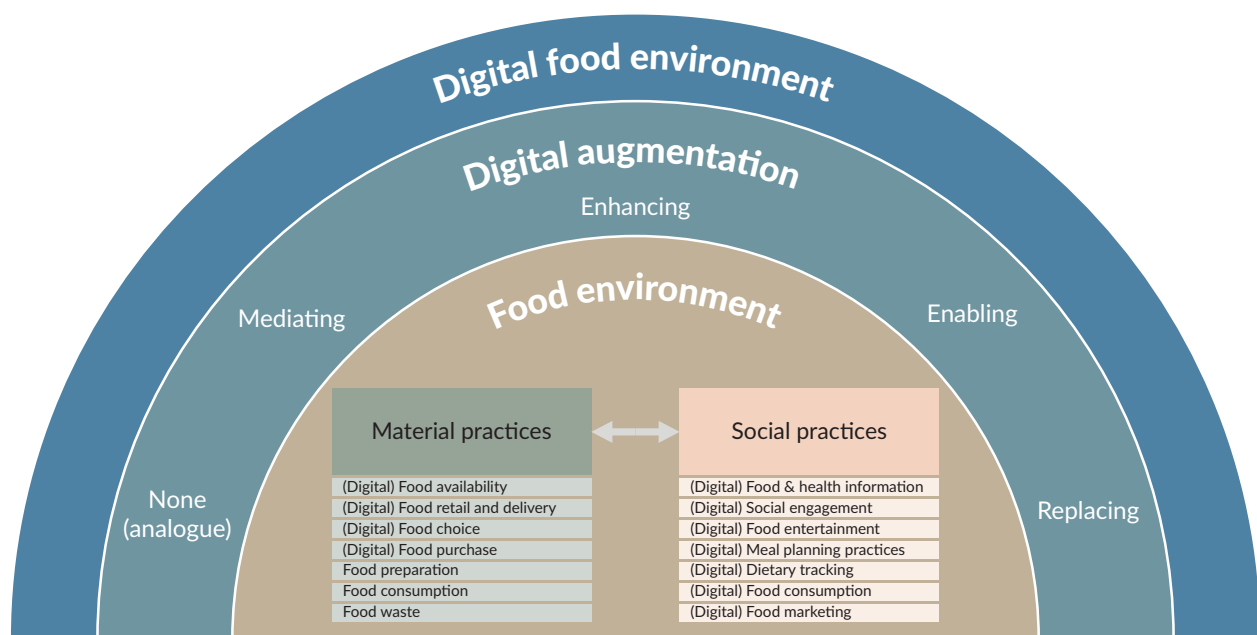


Figure 1. A visual representation of the definition of the digital food environment.

This definition is intentionally constructed to convey certain notions. First, and building on Henri Lefebvre's theory of space (Lefebvre, 1991), it frames the digital food environment as a *socially co-produced space*. This acknowledges that digital food environments are not naturally occurring phenomena, but rather a product of collective action, shaped in the dynamic interplay between social structures and agency. The digital food environment itself functions as a social structure that is shaped by the food practices enacted within it (agency) and, in turn, shapes those very practices, for instance by constraining or enabling healthy food choices, thus impacting directly and indirectly on nutrition, health, and equity.

More than static external contexts, interfaces, or physical settings where food is available, affordable, and purchased, digital food environments are conceptualized here as dynamic spaces where social and material food practices are enacted. This encompasses both physical and social dimensions of food, which are interconnected, inseparable, and of equal significance. For this reason, and aligned with critical realist ontology (Bhaskar, 1975, 2016), material and social food practices are depicted with equal prominence in the visual representations we constructed (Figures 1–3). This perspective contrasts with existing models of the food environment that tend to emphasize material aspects (Downs et al., 2020; Raza et al., 2020; Turner et al., 2018). Material food practices refer to the interaction with food as a tangible object, which can be

chosen, touched, prepared, exchanged, gifted, donated, purchased, transported, consumed, or discarded. Social food practices, on the other hand, extend beyond the material domain, encompassing the ways in which individuals engage with each other about food, how meals are shared, and how food is understood, desired, idealized, demonized, and promoted in society. The model presented in Figure 1 depicts the primary material and social food practices identified in this study.

Second, the digital food environment is conceptualized as an *augmented* space because it represents an expansion of the experiences, characteristics, functionality, and opportunities of analogue food environments through the use of digital technology. Material and social food practices can occur independently of digital technology but may also be digitally augmented to varying degrees. We represent this digital augmentation through five overlapping and interwoven levels: analogue, mediating, enhancing, enabling, and replacing. The inclusion of the first level, *analogue* (no digital augmentation), indicates that social and material food practices can still occur in analogue form even in highly digitalized societies.

Digitally mediated food practices refer to a level of augmentation where digital technology acts as an intermediary, a mediator for a transaction without fundamentally changing its character. This can be observed, for instance, in food purchases where the payment occurs digitally, but digital technology plays no other role in the decision-making and purchase processes.

Digitally enhanced food practices refer to a further level of augmentation, in which digital technology fundamentally changes the experience, physical spaces, or services by adding transformative features. For example, meal delivery apps are not a neutral mediator in the food purchase transaction. They have features such as push notifications, discounts, and user interfaces that are designed to promote and increase the frequency of purchase, shaping the types of meals purchased towards energy-dense foods of low nutritional quality (Bennett et al., 2024; Brar & Minaker, 2021; Fernandez & Raine, 2021; WHO EURO, 2021b). Other examples include meal subscription kits, online food retail, and digital ordering kiosks in physical restaurants.

Digitally enabled food practices have a level of augmentation where digital technology allows the existence of products, services, and interactions that have no materiality and exist purely as digital data, thus pertaining to practices occurring in cyberspace. Cyberspace refers to the medium created by computer networks such as the internet, where online communication, data exchange, and social networking occur, including digital settings such as social media platforms, websites, chat rooms, etc. (Castree et al., 2013; Dodge & Kitchin, 2001). Though supported by material technology infrastructure, digitally enabled food practices are immaterial and largely online. In focusing on online settings, existing digital food environment definitions (Bennett et al., 2024; WHO EURO, 2021a) align best with this level of digitalization, but insufficiently accommodate the additional dimensions proposed in our framework. An example of digitally enabled practices is food and nutrition-related support groups and communities in social media platforms, which create a social environment that does not necessarily exist outside of cyberspace (Giacoman et al., 2024; Jacobsen et al., 2017; Marcon et al., 2018; Pham et al., 2024; Supthanasup et al., 2021). Another example is the emergence of digital food influencers, often understood as “food celebrities” who communicate about food online, reaching broad and diverse audiences (Goodman & Jaworska, 2020, p. 184), whose very existence is only possible due to digital technology.

Digitally replaced food practices refer to those where digital technology displaces human transactions in the digital food environment, as human choices and activities are outsourced to non-human agents. The growing adoption of AI illustrates this, for instance, in AI analysis of consumer behaviour for autonomous targeting of digital food advertisement (Baek, 2023; Gao et al., 2023).

Third, impacts on nutrition, health, and equity are deliberately prioritized in the definition, reflecting the body of evidence linking these issues and recognizing that digitalization can contribute to widening social inequalities (Kickbusch et al., 2021). Moreover, the definition is intentionally non-directional with respect to outcomes, acknowledging that the digitalization of food environments has the potential to generate both beneficial and detrimental outcomes.

Finally, given that the digital food environment is socially co-produced (and therefore a social product; Lefebvre, 1991), each society, group, or individual *produces their own* digital food environment. Consequently, multiple digital food environments coexist, co-produced across various scales, and can be investigated at different levels of analysis. The issue of scale can be approached from different perspectives and epistemological traditions (Manson, 2008). In our analysis, we integrate elements from Bhaskar's seven-scalar laminated system (Bhaskar et al., 2017) and Bronfenbrenner's socio-ecological theory (Bronfenbrenner, 1977) to propose a stratification of scale in the digital food environment, which is itself represented here as a meso-level phenomenon (Figure 2).

The different layers of the model in Figure 2 are fluid, mutually constitutive, and influence each other (indicated by the arrow at the bottom left corner). The representation of fluidity is a limitation of this type of model, although it remains a useful and familiar tool for illustrating different scales and levels of complexity. While social and material food practices may be approached at the individual level, as implied in the model, they may equally be approached from an institutional perspective. Although the digital architecture is depicted

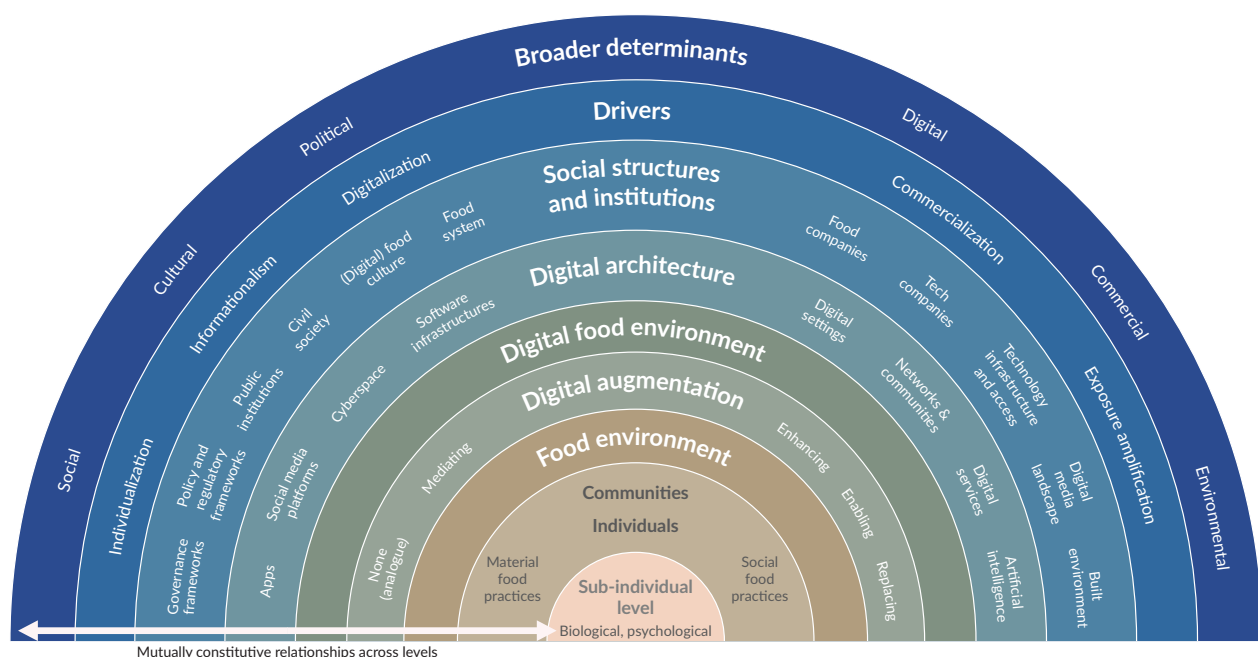


Figure 2. Levels of scale in the digital food environment.

as encapsulating the lower levels of the model, it simultaneously influences the upper levels. Additionally, the model in Figure 2 portrays levels of scale, but may inadvertently suggest that digital and analogue food environments can be separated. We argue, however, that it is impossible to fully disentangle the digital and analogue dimensions of the food environment in late modernity.

3.2. A Proposed Ontology for the Digital Food Environment

Our proposed ontology for the digital food environment is portrayed in Figure 3 following the realist Context–Mechanism–Outcome configuration (Pawson & Tilley, 1997). In our conceptualization, the digital food environment is ontologically positioned as a social structure that is co-produced in the interplay between different domains: (i) *agents* (human and non-human), who (ii) perform *social and material food practices*, which can be (iii) *digitally augmented* to varying degrees, and (iv) shape and are shaped by existing *social structures*, which in turn (v) exist in the context of *broader determinants* of health and equity. These interacting domains, illustrated through nested levels at the centre of Figure 3, are driven by *late modern processes*, and have a number of *outcomes* in relation to nutrition, health, equity, human rights, and the environment, which in turn feed back into all domains.

Over time, these domains and processes interact in a complex and interdependent dynamic, as human and non-human agents reproduce or transform the shape and character of digital food environments through their presence and activity, while simultaneously being enabled or constrained by social structures (including the digital food environment itself) and broader determinants. The arrows at the top right corner indicate the bi-directional flow between all components situated within these nested levels.

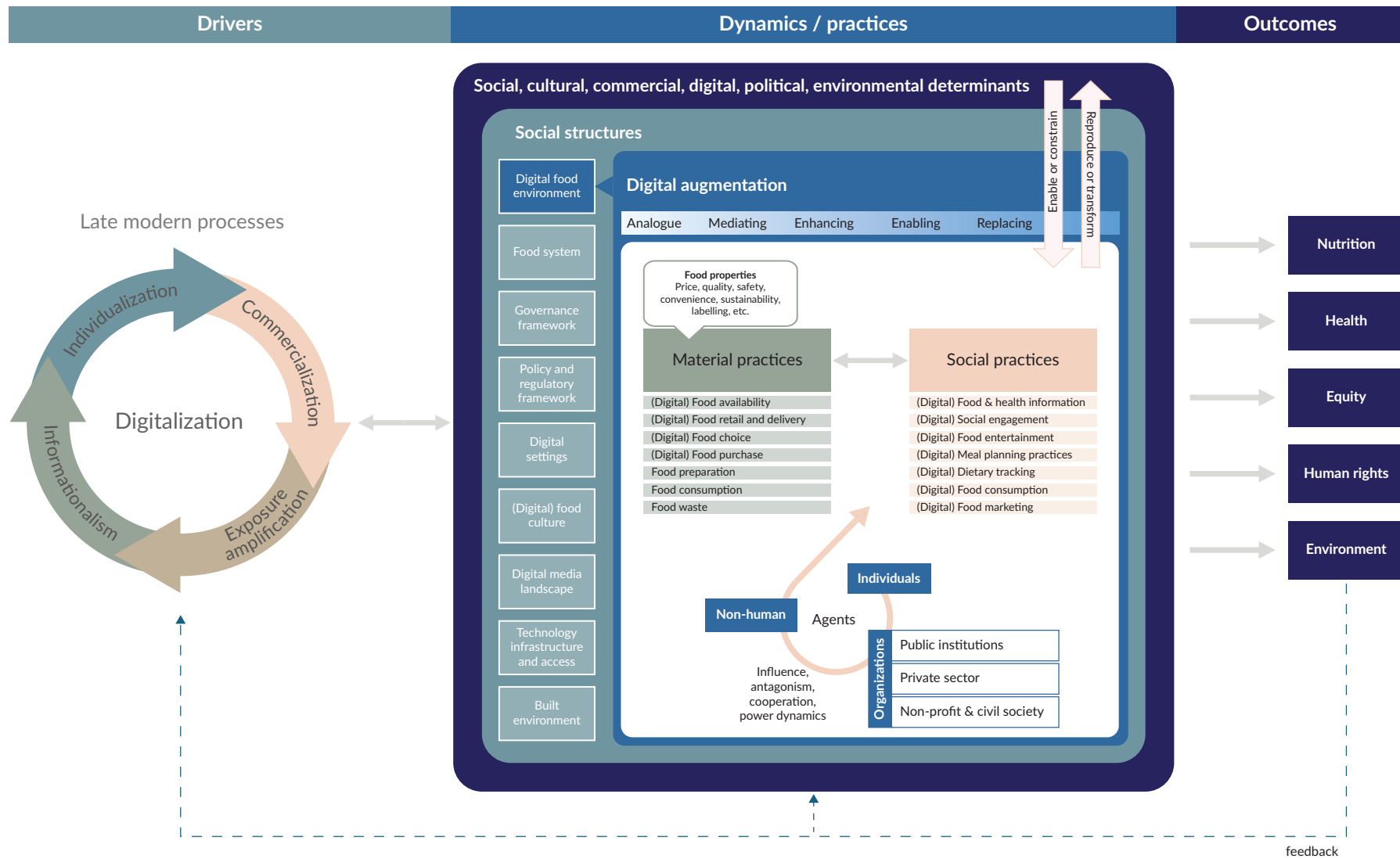


Figure 3. Ontological model of the digital food environment.

3.2.1. Agency in the Digital Food Environment

The digital food environment is socially co-produced over time in the interplay between the different actors who constitute it. In our proposed typology, we consider both human and non-human agents, each possessing distinct properties and characteristics, as illustrated in Figure 4. These properties are not fixed attributes, but rather dynamic elements which can be restructured over time, for instance towards more equitable outcomes (Graham, 2007).

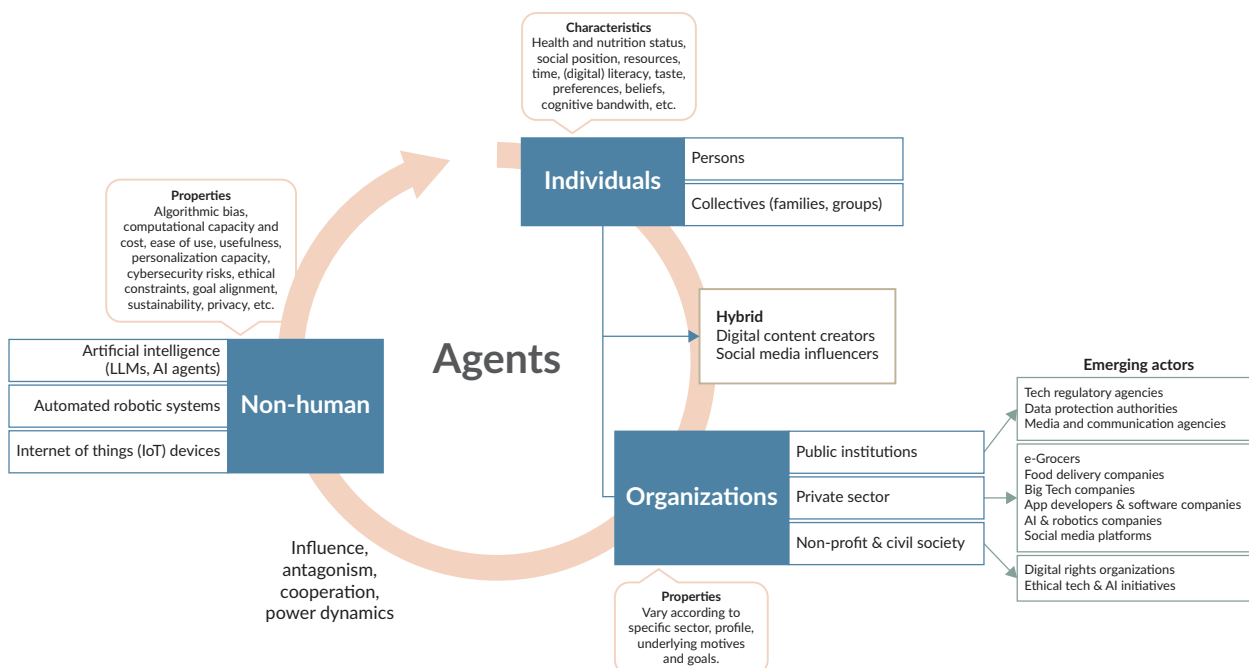


Figure 4. Typology of agents in the digital food environment. Note: Traditional food environment actors such as the food industry, food retailers, as well as governments and regulatory bodies in all sectors directly and indirectly related to food and health are omitted from this model for simplification purposes but are also part of the digital food environment governance.

Human agents refer to individuals as well as different types of human organizations. This includes the traditional actors in food environment governance, such as consumers, the food industry, food retailers, the advertising industry, governments and regulatory bodies, academic and research institutions, and civil society organizations (Kraak & Niewolny, 2024; Lobstein et al., 2013; Sacks et al., 2019). Food environments are, however, contested spaces with significant power asymmetries, particularly between the public and private sectors, where public health goals often conflict with the profit-oriented interests of commercial and quasi-commercial entities (Lacy-Nichols et al., 2023; Mialon et al., 2015; Moodie et al., 2021).

In the digital food environment, these complexities are amplified by technology companies, which have become integral to food environment governance. These actors create, provide, and enable food-related digital services, such as food delivery apps and aggregators (Traynor et al., 2022), dark/ghost kitchens (Hakim et al., 2023; Nigro et al., 2023), digital food marketing, and online food retail (e-Grocers). They have also contributed to the transformation of food into a digital commodity, understood as “an intangible product produced for profit but one that exists only in the electronic domain of bits and bytes” (Rotta &

Paraná, 2022, p. 1046). *Digital food commodities* encompass a wide range of products, from food imagery on social media (Ibrahim, 2015) to diet-tracking apps (Griffiths et al., 2018).

Technology companies include the major multinational technology corporations such as Alphabet, Meta, and Amazon (“Big Tech”), alongside app developers, AI companies, and social media platforms. They function as gatekeepers of digital food and nutrition information, with the power to either facilitate or hinder the dissemination of health- and nutrition-related (mis)information (Storeng & Puyvallée, 2021). They also provide the digital infrastructure through which user data are collected and leveraged for targeted digital food marketing, while enabling the rise of social media influencers (Abidin, 2016; Goodman & Jaworska, 2020; Miguel et al., 2024) as key actors in the digital food environment.

In our conceptualization, social media influencers and other digital content creators are a hybrid category of agents, given that they may act in a personal capacity but often operate as commercial entities rather than private individuals. They act as knowledge brokers, curators of information for the general public, and make food into entertaining content to be consumed (Granheim et al., 2025). Their action influences and shapes food culture, consumption habits, and the flow of narratives about food, nutrition, and health (Vilkaite-Vaitone, 2024). They have also become key figures in digital food marketing (Coates et al., 2019; Evans et al., 2024).

Furthermore, non-human agents are increasingly part of the digital food environment. The sociological understanding of non-humans as agents is not new (Latour, 2005; Lupton, 2017b). In our analysis, we identified the action of non-humans in the digital food environment, for instance, in the form of recommendation algorithms that shape social media feeds with digital food content curated and tailored for the individual (Bhandari & Bimo, 2022; Hermann, 2022), and in programmatic advertising through which the process of buying digital advertisement placements is automated, based on an individual's personal data (Nair & Gupta, 2021). In both these cases, the algorithms are responsible for deciding what digital content individuals will be exposed to, though generally guided by parameters provided by humans.

Non-human agency has recently become a more pressing issue due to advancements in generative AI, including large language models (LLMs) such as ChatGPT, which have become easily accessible and affordable to individual users. Although this field is new and rapidly developing, emerging evidence suggests that such technologies are currently being used to generate personalized meal plans and recipes based on user input and characteristics (Papastratis et al., 2024), as well as to provide nutrition information and dietary advice (Bayram & Ozturkcan, 2024; Niszczoła & Rybicka, 2023; Ponzo et al., 2024). We have also observed the use of generative AI to create digital food content in social media, including recipes, food videos, and advertisements. Emergent forms of AI, such as AI agents (a more advanced form of LLMs), are capable of making decisions and taking actions on behalf of humans even in the absence of explicit instruction sets from a human (Gutowska, 2024; Wiesinger et al., 2024). Agentic AI has the potential to fully displace human agency in key aspects of an individual's interactions with food, including determining what to eat, planning meals, and purchasing food. These examples suggest ways in which important food-related choices can be outsourced to AI, thus replacing human agency, although the reach of this application and the outcomes for health, nutrition, and equity remain unknown.

Thus, the digital food environment has a governance model in which technology companies, digital content creators, and non-humans have become key actors, enabling new, more sophisticated ways to shape consumer

behaviour, preferences, and purchases. The existence of a new governance model is corroborated by emerging research that increasingly recognizes the social media industry and digital media as commercial determinants of health (Even et al., 2024; Kenworthy et al., 2023; Lafontaine et al., 2025; Zenone et al., 2022).

3.2.2. Social Structures and Broader Social Determinants

Social structures generally refer to patterns of social relationships, roles, rules, and institutions that contribute to social order and cohesion, structuring individual and collective behaviour (Buch-Hansen & Nielsen, 2020; Giddens, 1984; Porpora, 2015). According to Bhaskar (2016), structures pre-date agency, yet they are reproduced or transformed through agency over time. We presented a number of social structures in Figure 3. The digital food environment itself is ontologically positioned as a social structure, which enables or constrains digitally augmented social and material food practices. For instance, the ordering of unhealthy meals is facilitated by meal delivery apps, where their presence is prominent by design, and persuasive digital marketing strategies are employed to promote sales.

Other social structures play a role in shaping the digital food environment and food practices. The food system is a social structure that links the digital food environment with the broader dynamics of food production systems that affect food availability, quality, sustainability, and price (Global Panel on Agriculture and Food Systems for Nutrition, 2016; van Berkum et al., 2018). Further, a precondition for the existence of the digital food environment is availability, affordability, and access to digital technology infrastructures and services. The degree to which a society is digitalized more generally will impact the degree of digitalization of the food environment.

Governance frameworks structure the organization and interaction of institutions by defining processes, roles, and responsibilities, while simultaneously being shaped by underlying power dynamics that influence their functioning and regulatory capacity. Within this context, existing policy and regulatory frameworks, as well as those that are lacking, constitute a critical social structure by establishing the rules governing agents that engage in digitally augmented social and material food practices. Regulation in the digital food environment presents new challenges. For example, digital food marketing has raised new concerns given its presence across national borders, the rapid evolution of marketing strategies driven by algorithmic personalization, and the blurred boundaries between user-generated and commercial digital content (e.g., influencer marketing; WHO, 2023a; WHO EURO, 2016). Although recent regulatory initiatives such as the introduction of food labelling standards for online food vendors (Joint FAO/WHO Codex Alimentarius Commission, 2024) represent progress, existing regulatory frameworks are likely to be insufficient to address the complexity and fluidity of the digital food environment.

Other key social structures are the digital media landscape, the built environment, the broader food culture, including the specificities of digital food culture, and digital settings. We understand *digital settings* as the places in cyberspace where people engage in their daily activities and interact with the digital food environment. This includes the different social media platforms (e.g., Facebook, TikTok, Instagram, Snapchat), chatrooms and messaging apps (e.g., WhatsApp, Messenger), websites, online supermarkets and other digital food vendors, food sharing platforms, online communities and forums (e.g., Discord, Reddit, Facebook groups), mobile health and nutrition apps (e.g., MyFitnessPal, Lifesum), content streaming platforms (e.g., YouTube, Twitch), among others.

In Figure 3, we depict social structures as taking place in the context of broader social, cultural, commercial, political, environmental, and digital determinants of health and equity, which have been extensively described in the literature (Dawes et al., 2022; Gilmore et al., 2023; Kickbusch & Holly, 2023; Marmot et al., 2010; Paltriguera et al., 2024; Rice & Liamputtong, 2023). Although there may not be a strict ontological distinction between social structures and social determinants, we opted to present them separately in the model for greater analytical clarity. This distinction makes it possible to highlight the key structural forces that directly shape the digital food environment, while also acknowledging the wider determinants (such as health systems, health promotion interventions, climate change, among others) that influence it more broadly but fall outside the scope of this study.

3.2.3. Late Modern Processes Driving the Digital Food Environment

This section describes the late modern processes that we identified as the major drivers of the digital food environment. Our theoretical framework in Figure 3 reflects a temporally situated configuration of the digital food environment, shaped by these processes. It does not represent a static or definitive model, but rather one contingent on the dynamics currently observed. Therefore, different societal processes may shape a different configuration for the digital food environment, for instance, at a different point in time or at a specific level of scale.

These drivers are portrayed in the left circle in Figure 3, with the process of *digitalization* placed at the centre of the circle, reflecting its dual influence both as a driver of the digital food environment and as a process affecting all other drivers. The recurrence of digital/digitalization/digital augmentation in different places of the model in Figure 3 may appear redundant but is intended to show how deeply embedded digital technology is at all levels, representing a cross-cutting process that permeates the entire system.

Digitalization is intrinsically tied to the production, processing, and circulation of information. It is a core driver of the informational flows that underpin contemporary social and economic systems. This process is closely linked to the logic of *informationalism*, as conceptualized by Castells (2010), who argued that society has entered a stage of development where information is the primary source of productivity, power, and social organization. Our “informationalised” society is profoundly dependent on the generation, processing, and transmission of information (Webster, 2014, p. 133), thus positioning digital information at the centre of our existence in late modernity.

In the context of informationalism, the digital food environment is co-produced through continuous flows of data and the meanings attributed to these data. Digital food commodities and services, as well as social practices such as the sharing of digital food photos with family and friends, seeking health and nutrition information via internet search engines, and consuming digital food content in social media, are, in essence, informational flows. The digital food environment is therefore not only underpinned by food (as a material object), but by the generation, circulation, and consumption of digital information.

Globalized flows of information intensify people’s need for a sense of identity, belonging, and personal value within an increasingly interconnected and often homogenized world (Castells, 2010). This increased need for turning attention to the self has been theorized as the process of individualization. *Individualization* refers to a late modern process through which traditional structures and collective certainties lose their guiding influence,

leaving individuals increasingly responsible for constructing their own life narratives, identities, and making reflexive choices (Beck & Beck-Gernsheim, 2002; Giddens, 1991).

Our analysis indicated that individualization influences both agency and structure in the digital food environment. On the one hand, individualization affects how people enact material and social food practices. Individuals increasingly develop their dietary habits through reflexive engagement with digital media, for instance by searching for food inspiration on social media or engaging in ongoing online food trends (Doub et al., 2016; Lavis, 2017; McInnes et al., 2023; Topham & Smith, 2023). There is also high interest in digital products and services that provide opportunities for self-monitoring and dietary customization, often based on ideals of health optimization, self-improvement, and convenience (Granheim et al., 2025; Lupton, 2018; Lupton & Jutel, 2015; Singh et al., 2019), the latter having been identified as a major driver of current food environments (Bogard et al., 2024).

On the other hand, individualization also contributes to the structuring of the digital food environment itself. Digital products and services are conceived with personalization as a core principle, designed to adapt to the unique needs, preferences, and lifestyles of users. The development of digital food commodities and services increasingly prioritizes features such as convenience, flexibility, and adaptability, attributes that enhance their appeal and therefore purchase and use. This dynamic is further intensified by AI, which enables mass personalization at an unprecedented scale, making digital content appear more relevant, engaging, and satisfying (Hermann, 2022). While this personalization may increase consumer satisfaction, it simultaneously serves commercial interests and risks reinforcing existing social inequalities, for instance by disproportionately affecting individuals with limited critical digital literacy skills, and through the collection and commodification of personal data without fully informed consent.

This is not to suggest that digital technology has failed to provide opportunities for collective action. On the contrary, it has enabled new modes of operation for alternative food networks and food sharing platforms, which strive for more sustainable and equitable food access (Granheim et al., 2021; Lewis, 2018; Micheleni et al., 2018; Rivera et al., 2023). However, these collective efforts remain marginal in relation to the dominant, commercially driven dynamics of current digital food environments.

Individualization, with its emphasis on reflexivity, personal choice, and self-management, has been interpreted as a manifestation of neoliberalism (Dawson, 2012; Lazzarato, 2009). In our study, we identified *commercialization* as a key process shaping and driving the digital food environment. It refers to the growth- and accumulation-oriented neoliberal ideology that promotes the expansion of individual entrepreneurial freedom and free markets. According to Harvey (1990, 2005), such neoliberal ideology assumes that unregulated market mechanisms will naturally generate growth and self-correct towards beneficial societal outcomes.

Commercialization shapes food practices by positioning choice as a personal responsibility, which underpins the current development of digital technologies. The proliferation of highly personalized digital food commodities and services reflects the underlying market logic of continuous innovation and profit maximization. For example, we observed that nutrition-related smartphone apps have become widespread, as software developers compete to sell tools for dietary management, meal planning, and health monitoring, designed to maximize user appeal through convenience and adaptability. Similarly, food retailers and

delivery platforms increasingly deploy personalized discounts and product recommendations to enhance consumer engagement and increase sales.

Further, the strategic incorporation of social media influencers and other digital content creators as marketing agents contributes to creating a consumerist social media environment, where consumption is normalized and incentivized (Khamis et al., 2017; Sikka, 2019). These practices often exploit consumer vulnerabilities, negative self-perception, and dissatisfaction with their own bodies, diets, and lives, impacting people's emotional well-being as they need to navigate the market logics of neoliberalism when enacting food practices (De Souza, 2025). Neoliberal ideology shapes the role and value of bodies in the market, assigning blame for bodies that deviate from societal norms (Ivancic, 2018).

This effect is amplified by the ubiquity of digital body and food imagery, which characterizes the *exposure amplification* process we identified as a driver of the digital food environment. We observed that food imagery and messaging are embedded across various digital platforms and services, leading to an amplified exposure to *food*, which, beyond a material product, has become digital content, circulated through advertisements, social media posts, recipe tutorials, cooking videos, and entertainment media. Further, we observed that exposure to *body* imagery is also amplified. Digital content creators provide visibility to diverse body types, personal body transformation stories, and fitness tutorials, which can promote inclusivity and reinforce the narrative that all bodies have worth (Cwynar-Horta, 2016; Sastre, 2014). However, this positive narrative frequently coexists with—and is likely overshadowed by—digital content reinforcing unrealistic and unhealthy body ideals, impacting health negatively (Fioravanti et al., 2022; Holland & Tiggemann, 2016).

We argue that, in the digital food environment, this duality of exposure celebrating diversity while perpetuating neoliberal-driven normative ideals is shaped by commercial agents, fostering confusion, cognitive overload, and the internalization of unattainable expectations regarding own diets, bodies, and health. Regardless of whether the messaging is framed positively or negatively, the persistent exposure to food and bodies in digital settings carries implications for nutrition and health. The volume and pervasiveness of digital food content can subtly but cumulatively influence food choices and consumption patterns in ways that are difficult to identify and measure. We argue that the ubiquity of such content within daily digital food practices increases the likelihood of its impact over time. As indicated by van Kessel et al. (2025), by being heavily exposed to digital transformations, even younger and healthier populations are at risk of its adverse effects.

The dynamics of digital exposure risk exacerbating existing social inequalities. Opportunities to opt out of this exposure are limited and often challenging to navigate, raising concerns about real opportunities to exercise agency and autonomy in technology choices (Kuntsman et al., 2019; Taylor, 2017). When individuals are compelled to exchange personal data for economic incentives, such as discounts offered through supermarket apps, those most in need of financial relief may lack a genuine ability to opt out of paying less. When the social norm is to consume digital food content regularly, groups with lower levels of digital literacy may be unequipped to critically assess the credibility, intentions, and potential impacts of the content they engage with, leaving them more vulnerable to persuasive marketing, misinformation, and unhealthy dietary influences.

3.2.4. Outcomes

The model in Figure 3 indicates that the dynamics of the digital food environment, driven by digitalization, informationalism, individualization, commercialization, and exposure amplification, may have impacts on nutrition, health, equity, human rights, and the environment. Our study did not map or measure specific outcomes. Previous studies have indicated that digitalization of the food environment may be impacting food choices, purchases, and intake, as well as body dissatisfaction, and thereby health and nutrition outcomes (Granheim et al., 2021; Lafontaine et al., 2025; Powell & Pring, 2024). However, this is an emerging area and further investigation is needed.

Recent studies have also explored ways in which the digital food environment may promote equitable access to healthy and sustainable diets (Greenthal et al., 2024; He & Chen, 2024; Powell & Pring, 2024), indicating the potential to leverage digital technologies in that direction. Nevertheless, access to digital tools, digital literacy, and meaningful engagement with health-related resources remain unevenly distributed (Badr et al., 2024). Digital technologies can both reflect and reproduce structural inequalities, hence the impacts of the digitalization of the food environment are likely to be uneven globally and in relation to sociodemographic groups.

3.3. Comparing Traditional Food Environments and Digital Food Environments

The elements that compose traditional food environment models are accommodated within our conceptualization of the digital food environment. They fall, for the most part, under material food practices, which include food properties such as nutritional value, quality, price, sustainability, safety, convenience, among others. In our proposed models, however, social practices and the interplay between all domains become more evident.

Not all aspects of the digital food environment represent entirely new practices. Many food practices we observed have historically existed in the context of the food environment and endure, coexisting alongside and entangled with digital practices. While people now watch cooking shows and other people eating through live-streaming on digital platforms (Lee & Wan, 2023), audiences have enjoyed cooking programs since the advent of television (Collins, 2015), and likely observed each other in cooking and eating situations in domestic or community settings before television existed. Similarly, social media platforms facilitate engagement and community building around shared interests, including food, but these activities traditionally occurred in physical spaces where individuals gathered. While self-tracking apps now help individuals monitor their diets on smartphones (Lupton, 2019), some people earlier kept physical food journals. While it is now common practice to search for recipes and health information online (X. Jia et al., 2021), people earlier consulted cookbooks, diet guides, and magazines for similar insights.

The distinction lies in the speed, reach, and volume of digitally augmented practices. A defining feature of digital technology is its capacity to exponentially expand the reach and speed of information dissemination. Unlike traditional media, where content distribution was more predictable, subject to editorial control and temporal limitations, digital food content is spread globally within seconds. Algorithms further amplify this reach by prioritizing content based on engagement metrics (e.g., likes, shares, comments), rather than considerations of accuracy, reliability, or public health value. Information and inspiration are now available

instantly and continuously, with digital food content being ubiquitous in unprecedented ways. The convenience and ease of use of digital food tools and services facilitate engagement, exposing individuals to ideas, trends, and products they might never have encountered otherwise.

This amplified pace, constancy, and breadth of digital exposure create a food environment that is more persuasive and immersive than ever before. We argue that the relentless flow of digital food information, for example in the form of new apps, new food trends on social media, and the frequent appearance of food in digital media outlets, creates barriers to establishing stable and health-promoting societal narratives about food and nutrition. The sheer volume of digital food information available makes navigating the digital food environment more cognitively demanding than traditional food environments, requiring advanced critical and digital health literacy levels, hence potentially widening the digital divide.

4. Limitations of This Study

The theoretical framework we have proposed offers a broad and flexible approach to understanding the digital food environment. It is intended as an ontological model that identifies key dynamics shaping social and material food practices in late modernity, rather than describing definitive categories. In a study of this nature, it was not possible to measure direct impacts on health or nutrition outcomes. Future research can build on this foundation to conduct in-depth empirical investigations into specific components of the model, as well as explore the extent and direction of outcomes.

We recognize the Western-centric orientation of this model. Our elicited data were collected in Norway, and the extant data draw primarily on studies conducted in high-income, Western contexts, reflecting the current availability of research in this area. Integrating perspectives from low- and middle-income countries requires further research to explore how processes associated with late modernity, such as urbanization and uneven digital access, can be taken into account, in addition to the multiple burden of malnutrition in all its forms affecting these countries. Adapting the model to reflect these diverse realities would improve its explanatory power and applicability. Future studies could apply similar grounded theory approaches to explore the locally situated dynamics of digital food environments across the globe.

Moreover, our analysis did not evaluate interventions or emerging approaches in the digital food environment that leverage digital technology for improved health, nutrition, and equity. This remains an important gap, as understanding the effectiveness, accessibility, and, crucially, the ethical implications of such innovations is essential for informing evidence-based policy and practice in late modernity.

5. Policy Implications

While theoretical in nature, our model has practical implications for advocacy, policy, and regulatory efforts. It challenges the adequacy of purely technocentric solutions (such as the proliferation of individual health apps) that often overlook the complexity of social food practices and the interplay between agency and broader social structures that we have illustrated in the framework. Current public health challenges, including noncommunicable diseases, equity, and planetary health, require more than utilitarian, individualized, technology-driven interventions. They demand attention to the complex and often unintended consequences of technology on social practices.

Further, the convergence of powerful commercial and quasi-commercial entities in the technology and food sectors will likely amplify existing power asymmetries in food environment governance, framing social structures in ways that benefit these entities and align with their goals. The involvement of public health professionals in discussions on digital technology regulation and AI moving forward may support the development of policies and regulations that are in line with public health goals.

National guidelines addressing food and nutrition challenges would benefit from acknowledging the embeddedness of digital technologies in the everyday food practices of both individuals and organizations. Our theory of the digital food environment indicates that agents such as social media influencers and AI are not peripheral influences. They have become integral to food practices in late modernity. Further, research and action on the digital food environment should consider that non-human agents are neither neutral nor static entities. They too are a social product that can be designed and governed in ways that either reinforce or challenge existing power relations and social inequalities. In the context of rapid technological change and the increasing role of non-human agents, the protection of human rights (such as the right to health and the right to adequate food) needs to be strengthened. The digital food environment, as a socially co-produced space, could be regulated in ways that serve the public interest, prioritizing public health goals over commercial or technological imperatives.

Existing policies and regulations need strengthening, for instance, with regard to the regulation of digital food marketing, personal data protection, and requirements for transparency and accountability in algorithmic systems that influence food practices (e.g., how food is digitally recommended or promoted). Additionally, the equitable promotion of digital food literacy and critical thinking skills (including regarding AI use) from an early age is essential so that individuals are better equipped to engage critically with their digital food environments and challenge structural constraints.

Finally, growing attention should be paid to rising forms of human–technology interaction. Wearables that monitor physical activity, diet, and body metrics are already commonplace, and emerging forms of human enhancement (such as neural or subcutaneous implants) are progressing the integration between human and non-human agents, thus warranting further investigation.

6. Conclusion

This study set out to conceptualize the digital food environment within the context of late modernity, recognizing digitalization as a transformative force reshaping food environments. Our proposed ontology for the digital food environment recognises its nature as a socially co-produced augmented space, and its function as a social structure shaping and shaped by (social and material) food practices, where digital technology mediates, enhances, enables, or replaces such food practices. The framework illustrates the dynamic interplay between (human and non-human) agency and social structures, driven by late modern processes such as digitalization, informationalism, individualization, commercialization, and exposure amplification. These dynamics generate both opportunities and challenges for nutrition, health, equity, human rights, and environmental sustainability.

Existing power asymmetries among human agents, such as those between public and commercial entities, are exacerbated in the digital food environment by the inclusion of technology companies in food

environment governance. The ontological foundation of our framework provides theoretical contributions to challenging the neoliberal assumption that food choices are a product of individual responsibility, which has been intensified in the context of late modernity.

By making visible the complex interdependencies between structure and agency, our study advances the theoretical foundation for future research and policy, highlighting the need for policy approaches that address the digital dimensions of food environments, ensuring that technological advancements serve public health and equity objectives to avoid widening existing social inequalities. Policies and regulations to promote healthy food environments must consider their increasingly digitalized nature.

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Conflict of Interests

The authors declare no conflict of interests.

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