Global Food Security 27 (2020) 100436

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs

Conceptual framework of food systems for children and adolescents

Ahmed Raza [a,*], Elizabeth L. Fox [b,c,d], Saul S. Morris [e], Roland Kupka [f], Arnold Timmer [e,g], Nita Dalmiya [f], Jessica Fanzo [b,h,i]

[a] Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
[b] Berman Institute of Bioethics, Johns Hopkins University, Baltimore, MD, USA
[c] Department of Population Medicine and Diagnostic Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY, USA
[d] Master of Public Health Program, Cornell University, Ithaca, NY, USA
[e] The Global Alliance for Improved Nutrition, Geneva, Switzerland
[f] The United Nations Children's Fund (UNICEF), NY, USA
[g] Iodine Global Network, Seattle, WA, USA
[h] Johns Hopkins Nitze School of Advanced International Studies, Johns Hopkins University, Washington D.C., USA
[i] Department of International Health, Johns Hopkins Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA

ARTICLE INFO

Keywords:
Food systems
Nutrition
Diets
Children
Adolescents
Conceptual framework

ABSTRACT

Transforming food systems is essential to ensuring nutritious, safe, affordable, and sustainable diets for all, including children and adolescents. This paper proposes a new conceptual framework (the '*Innocenti* Framework') to better articulate how the diets of children and adolescents are shaped by food systems. The framework is comprised of a set of food system drivers, determinants (namely, food supply chains, external food environments, personal food environments, and behaviors of caregivers, children and adolescents), influencers, and interactions, which together determine children's and adolescents' diets. The conceptual framework conceptualizes the dynamic linkages between the elements of food systems, and highlights the importance of continuously shaping food systems to deliver nutritious, safe, affordable, and sustainable diets to children and adolescents.

1. Introduction

Malnutrition in all its forms – undernutrition, micronutrient deficiencies and overweight and obesity – affects all countries around the world. Children and adolescents are among the most vulnerable groups affected. Globally, approximately 144 million children under the age of five are stunted, and over 38 million children under the age of five and 337 million children and adolescents between the ages of five and sixteen are overweight (UNICEF/WHO/World Bank, 2020; NCD-RisC, 2017). In addition, the diets of children and adolescents remain deficient in foods optimal for a healthy diet, such as fruits and vegetables, whole grains, fibers, nuts and seeds, and with limited free sugars, sugary snacks and beverages, processed meat and salt (WHO, 2018). Diets for children in low- and middle-income countries are particularly at risk where only one in four children (aged 6–23 months) receive a diverse diet necessary for growth and development (UNICEF, 2018).

Ensuring nutritious, safe, affordable, and sustainable diets for children and adolescents is a major development challenge (Kupka, Siekmans, & Beal, forthcoming in this special issue). Food systems are critical to addressing the multiple burdens of malnutrition that children and adolescents face, as food is a key determinant for healthy diets and good nutrition throughout the entire life course. Increasing attention has been placed in recent years on transforming food systems such that they ensure healthier diets and lead to positive nutrition outcomes (ICN2, 2014; Global Panel, 2014; HLPE, 2017). However, most of these efforts to transform food systems have not prioritized children and adolescents as key stakeholders. Although the food system should, of course, deliver healthy food to all, there is a need to explicitly focus on children and adolescents given their unique nutritional and dietary needs and their susceptibility to actions across the food system that adversely impact their diets.

Childhood and adolescence are critical periods for growth and development, and children and adolescents require key nutrients to support optimal growth trajectories. Beyond having unique dietary needs, numerous characteristics differentiate children and adolescents from other populations in terms of how they engage with their food systems. Children and adolescents are particularly susceptible to advertisements and marketing (Smith et al., 2019; Kelly et al., 2019),

* Corresponding author. Viale delle terme di Caracalla, c/o FAO, Rome, Italy.
E-mail address: Ahmed.raza@fao.org (A. Raza).

https://doi.org/10.1016/j.gfs.2020.100436
Received 21 March 2020; Received in revised form 2 September 2020; Accepted 4 September 2020

which can influence their desire for certain diets as well as their future dietary preferences. Children and adolescents also interface with school food environments and the foods available around those environments, and with expanding agency and independence as they get older, may select less than optimal food choices given the impact of peers and other influencers (Fox & Timmer, under review for this issue). Additionally, the role of different gatekeepers (e.g., parents, school teachers, etc.) changes as children get older, and this dynamic is often not captured or integrated into food-systems approaches. Establishing the diets of children and adolescents as the primary outcome of food systems helps to align actors across the food system towards the common goal of supporting the dietary needs of children and adolescents. This is an important step given the wide range of communities engaged in food systems and the often divergent priorities and understandings of potential problems and solutions (Bene et al., When food systems meet sustainability – Current narratives and implications for actions, 2019a).

Food systems involve people that initiate or inhibit change in the system, as well as the social, political, economic and technological environment in which food systems-related activities take place (FAO, 2013). This includes children and adolescents themselves, as well as their caregivers and others they interact with in their food environments. A food systems framework that explicitly focuses on how children and adolescents respond to and engage with activities, inputs, and outputs across the food system (including those related to food production, processing, marketing, consumption and disposal (FAO, 2013), can better illuminate gaps and opportunities to address their dietary needs. Currently, caregivers are viewed as responsible for determining the foods children and adolescents consume. However, a framework that shows how actors across the food system, in its totality, shape the diets of children and adolescents can help to identify actions that are needed to achieve transformational changes in the nutritional status of these groups.

This paper makes an initial contribution to the literature by proposing a conceptual framework that specifically examines children's and adolescents' diets and their connection to elements of food systems. It aims to strengthen the narrative on child- and adolescent-specific considerations in the food-systems transformation agenda. The framework focuses on the totality of the system, including interactions and feedback loops between its various elements. Cognizant of the challenges governments and development practitioners face in governing their food systems, this paper also identifies potential actions across the food system to improve diets of children and adolescents.

2. Evolution of food systems frameworks

The concept of food systems is not new. There have been several attempts to conceptualize food systems with a focus on nutrition. Sobal, Khan and Bisogni (1998) proposed one of the earliest conceptual frameworks. They modeled the full scope and structure of a food and nutrition system, by considering processes and transformations that take food from producers to consumers, and their linkages with other systems in the biophysical and social environments.

Later frameworks incorporated interactions between food systems outcomes and drivers to show the dynamic nature of food systems. Food system drivers are processes and structural factors that affect the functioning of food systems and are essential for ensuring nutritious, safe, accessible and sustainable diets. These frameworks showed that drivers exogenous to the food system (e.g., climate change, demographic changes, urbanization) play a critical role in food system transitions and transformations (Ericksen, 2008). In this way, these frameworks revealed the way in which these drivers affect people's access and choices around food. These frameworks also enabled analysis of synergies and trade-offs between different societal objectives, such as food security, environmental and social welfare outcomes, within the system to identify entry points for the design and prioritization of interventions (Ericksen, 2008; Ingram, 2011).

More recent conceptual frameworks have brought attention to the critical role food systems play in ensuring healthy and sustainable diets. The conceptual framework developed by Lawrence et al. (2015) characterizes food systems as the mediator between environment and public health nutrition outcomes. The framework proposed by the Global Panel on Agriculture and Food Systems for Nutrition (2014) also proposes relationships between the major elements of food systems, namely, agricultural production, market and trade systems, food transformation and consumer demand, and consumer purchasing power, and identifies possible policies, programs and interventions that can influence better diets and nutrition.

The UN High Level Panel of Experts (HLPE) Report on Food Systems and Nutrition 2017 was instrumental in improving the conceptual understanding of the linkages between food systems, diets and nutrition (HLPE, 2017). The report builds on earlier frameworks (e.g., Lawrence et al., 2015; Global Panel, 2014) to characterize diets as a core link between food systems and their health and nutrition outcomes. More distinctively, it elaborates on the role of food environments in facilitating sustainable consumer food choices. Food environments refer to the physical, economic, political and socio-cultural contexts through which consumers interact with food systems to purchase, prepare and consume food (HLPE, 2017). The role that food environments can play in shaping dietary patterns, especially in the context of the double burden of malnutrition, has gained traction in recent years (Herforth and Ahmed, 2015; HLPE, 2017). In the framework developed by Mozaffarian (2016), food environments are a key determinant that inform how people make choices around food (Mozaffarian, 2016). Turner et al. (2018) also investigate the relationships between food environment, nutrition and dietary outcomes.

Most of these conceptual frameworks, however, are not contextualized according to the vulnerabilities of groups most in need. In addition, to our knowledge, none of those frameworks takes a child- or adolescent-specific lens when considering interactions between the elements of food systems and nutrition and health outcomes. The conceptual framework for food systems and children's and adolescents' diets proposed in this paper aims to bridge this gap in literature. The ultimate aim of the framework is to highlight entry points for policymakers to help them to design and implement policies and programs that have the potential to shape food systems such that children and adolescents have access and availability to nutritious, safe, affordable and sustainable diets. With this focus, we do expect that a framework specifically focused on the diets of children and adolescents will have reverberating benefits for other nutritionally vulnerable and marginalized groups, such as pregnant and lactating women and elderly populations, as well.

3. Methodology

The development of the conceptual framework was led by representatives from FAO, Johns Hopkins University, GAIN and UNICEF, and builds on other papers in the supplement (Kupka et al, 2020; Fox & Timmer, under review for this issue). The framework supported the outcomes of a global consultation on food systems for children and adolescents that was held in November 2018 at *Innocenti* Research Centre, Florence, Italy. The 2017 HLPE report on nutrition and food systems served as a basis in the process, given the report's consensus-based approach and relevance to agenda setting at global, regional and country levels. The authors of this paper also drew from the conceptual framework proposed by Turner et al. (2018) to further explore food environments and their role in shaping dietary patterns.

Two rounds of reviews were sought from researchers with a background in agriculture, food systems, and children's and adolescents' nutrition to ensure that the conceptual framework was grounded in latest evidence. The conceptual framework presented in this paper also includes feedback and comments received from participants during the *Innocenti* consultation.

4. *Innocenti* Framework

The *Innocenti* Framework (Fig. 1) conceptualizes the linkages between the various elements of food systems and children's and adolescents' diets. The elements of food systems include food system drivers, determinants, influencers and interactions that are part of the system (Table 1).

4.1. Food system drivers

Food system drivers play a key role in improving our understanding of the dynamics and transformations in system. A recent literature review by Bene et al. (2019b) reveals that there is lack of a clear definition for food systems drivers, which leads to an inadequate understanding of system level changes and inability to support policymakers in designing and implementing policies and interventions. Building on HLPE (2017), food system drivers are processes and structural factors that affect the functioning of food systems in delivering safe, affordable, accessible and nutritious diets.

The Framework identifies five drivers, covering aspects of demographic change, political and economic environment, technological advances, natural resource management and social and cultural norms, all of which function in an integrated manner and could have endogenous and exogenous impacts on the food systems (Supplementary Materials, Figure S.1). For instance, exogenous pressures of population growth and urbanization challenge the ability of food systems to meet the nutritional needs of children and adolescents (UNICEF, 2019). Due to urbanization, older adolescents are often the ones to move to urban settings to support their families (Juarez et al., 2013; Temin et al., 2013), and the food environments in those settings might make it difficult for them to achieve their needs.

Similarly, there are endogenous pressures that can affect the capacity of food systems to sustainably deliver healthy diets for children and adolescents. For instance, poor agricultural practices and natural

Table 1
Terms related to the *Innocenti* Framework (Adapted from UNICEF, 2019).

Elements of the food system are all of the drivers, determinants, influencers, and interactions represented in the food systems framework, together.

Drivers are processes and structural factors that affect the functioning of food systems in delivering nutritious, safe, affordable, and sustainable diets.
Determinants are the processes and conditions across the food system, from production through to consumption, that are necessary to improve the diets of children and adolescents. The *Innocenti* Framework is comprised of four determinants: food supply chains, external food environments, personal food environments, and behaviors of caregivers, children and adolescents.
- **Food supply chains** are the actors and activities involved in food production, storage, distribution, processing, and packaging.
- **Food environments** are the physical, economic, political, and socio-cultural context by which consumers interact with food systems to procure, prepare, and ultimately consume foods. They are separated into two complementary food environments: external and personal.
  - **External food environments** are the retail and commercial markets, schools, and informal vendors where consumers interface with food, and reflect aspects of availability, food price, marketing and advertising, and vendor and product properties (e.g., vendor hours, food offered, etc.)
  - **Personal food environments** are the individual and household-level factors that consumers bring to the food environment, such as purchasing power, access, convenience, desirability, and informs why people choose to procure the foods that they do.
- **Behaviors of caregivers, children, and adolescents** are the procurement, preparation, supervision and eating practices of children, adolescents, and/or their caregivers.

Influencers are the more immediate and individual-level factors that determine the extent to which a determinant contributes or fails to contribute to delivering nutritious, safe, affordable, and sustainable diets. For the purposes of this manuscript, the influencers provide information about potential entry points for policy makers and practitioners.
Interactions are the linkages and feedback loops between the various elements that indicate how different determinants positively and negatively reinforce one another.
Diets of children and adolescents are the quantity, frequency and quality of different foods and drinks that children and adolescents consume, and are the outcome of the *Innocenti* Framework.

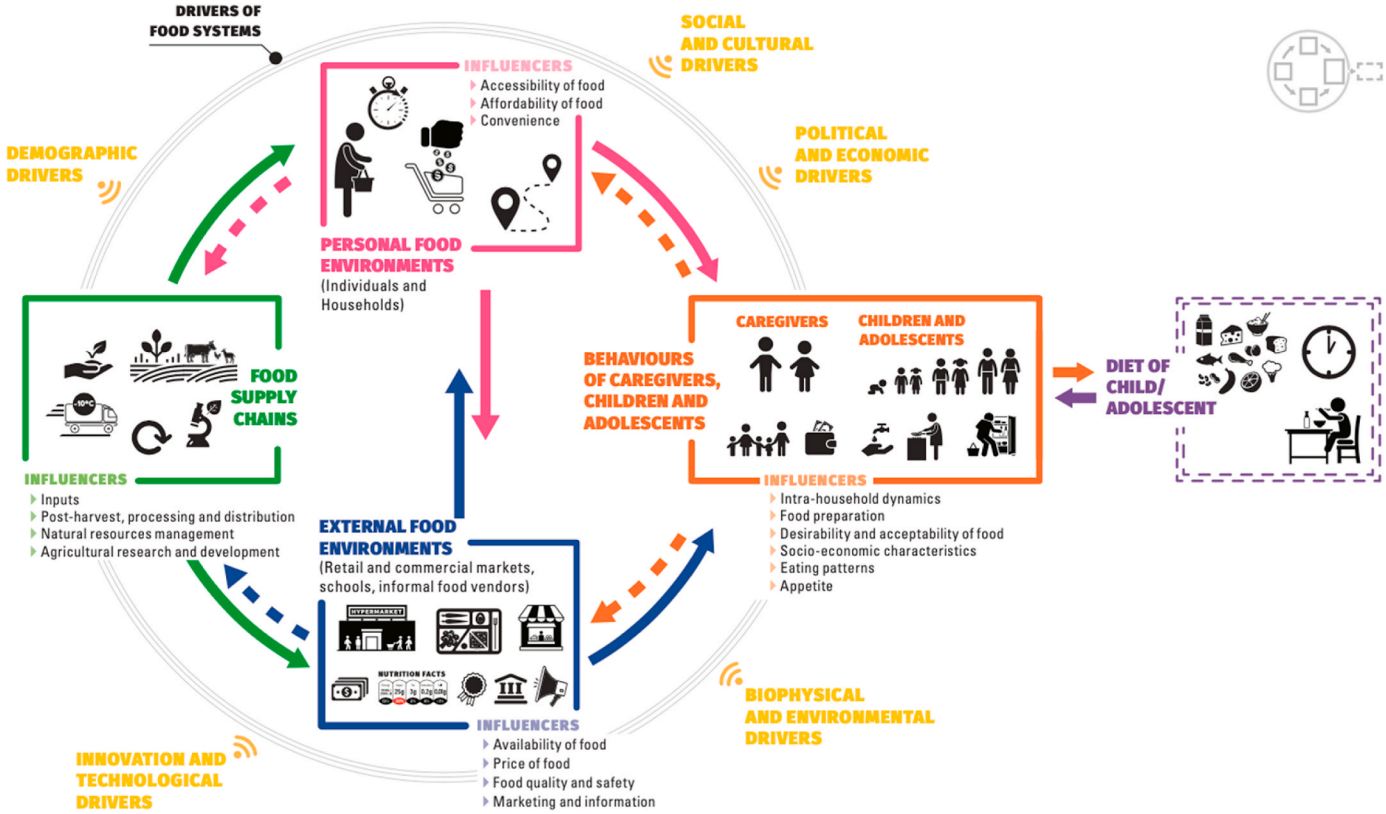

Fig. 1. The Innocenti Framework for food systems and children's and adolescents' diets (UNICEF and GAIN, 2019).

resource management, coupled with increasing demand for resource-intensive commodities, can lead to higher environmental degradation and greenhouse gas emissions.

4.2. Food supply chains and influencers

Food supply chains (Supplementary Materials, Figure S.2) are central to transforming agriculture and food systems for the promotion of better nutrition outcomes for children and adolescents. Food supply chains comprise all activities and actors involved in the production, post-harvest management, retail, marketing, consumption and the disposal of food (Hawkes and Ruel, 2012). In essence, they represent the linkages or 'chain' of processes that take food from production to consumption. There are multiple entry and exit points for nutrition that exist across food supply chains (Downs and Fanzo, 2016; Fanzo et al., 2017), that can make food supply chain activities more or less sensitive to the dietary needs of children and adolescents (Nordhagen, under review for this issue). However, food supply chains activities are not necessarily specific to children and adolescents (i.e., producers typically do not target their foods for children and adolescents). Indeed, a food supply chain that provides healthy foods to children and adolescents has the potential to also benefit the diets of other vulnerable groups and communities.

4.2.1. Inputs

Building on the work conducted by Downs and Fanzo (2016), Fanzo et al. (2017) and HLPE (2017), the *Innocenti* framework identifies inputs as critical to shaping food supply chains such that they promote better nutrition and diets for children and adolescents. As small- and medium-scale farms produce over 50% of the world's food (Herrero et al., 2017), the choices these producers make are central to ensuring nutritious, safe, affordable and healthy diets for children and adolescents. However, small-scale farmers often face constraints that impede them from diversifying food production. They face challenges relating to lack of access to inputs (such as, seeds, fertilizers, traditional varieties, etc.), land tenure, credit, and extension services (FAO, 2017). Extension services, in particular, were neglected for decades but have the potential of providing training and management skills to farmers to adopt nutritious varieties and promote crop diversification (Global Panel, 2014).

The diversification of food production is important for improving the access and availability of diverse foods for children and adolescents who require diets with fruits, vegetables and animal-sourced foods for optimal growth and cognitive development. There is a need to support small- and medium-scale farmers who invest and take risks in aligning their production practices with the dietary needs of children and adolescents, particularly given investments and inputs needed to do so and limited demand of some of these foods in the community. There are unique opportunities to link production of these foods (and associated inputs) to children's and adolescents' diets. For instance, securing a market for these foods through partnerships with schools and other institutions. Such alignment might make such input investments achievable for producers given secured markets. This can benefit farmers and producers, as well as children, adolescents, and their communities.

Agriculture practices in some contexts can also lead to deleterious effects on the health of children. Children are often engaged as laborers in various stages of food production. According to an estimate, 108 million children between the age of 5 and 17 are engaged in agricultural labor worldwide (ILO, 2017). Not only does the involvement of children in food production makes them vulnerable to occupational hazards, but also exposes them to pesticides and fertilizers that can disrupt the endocrine system and lead to cancer and delayed neurodevelopment later in life (UNICEF, 2019).

4.2.2. Post-harvest, processing and distribution

Many nutritious foods that are critical for the growth and development of children and adolescents, such as fruits and vegetables, seeds, nuts, animal-source foods, and seafood, are vulnerable to food loss and waste as they are highly-perishable, costly to produce and susceptible to pests and diseases (Global Panel, 2018). FAO estimates that almost 14% of world's food is lost from post-harvest up to the retail level (FAO, 2019). Investments in building appropriate infrastructure and technologies can reduce food loss and waste, and better support the movement of nutritious foods to markets.

Food processing and packaging play a critical role in reducing food loss and waste by enhancing the bioavailability of nutrients and improving sensory characteristics and properties of food, as well as by destroying foodborne microbes and toxins and improving food safety (von Boekel et al., 2010; Augustin et al., 2016). Beyond processing, storage and distribution of nutrient-rich foods also present opportunities to conserve nutrient content. In this regard, facilities such as cold chain storage and transport infrastructure can ensure greater availability of nutritious foods for households, and children and adolescents. Proper post-harvest management also play a role in ensuring food safety, especially in low- and middle-income countries. For instance, staple foods need to be properly dried and stored to avoid contamination with mycotoxins which have shown to lead to serious health conditions and malnutrition in children (Gong et al., 2002; IFPRI, 2012). Although food safety impacts all populations, young children are particularly susceptible to foodborne pathogens given the negative impact of poor absorption and diarrhea on their growth (Guerrant et al., 2008). Post-harvest and processing approaches that align with food safety measures, can reduce this risk.

In addition, food processing in the supply chain can also involve value addition (Gelli et al., 2015; FAO, 2018a). For instance, value additions relevant to children and adolescents include food fortification, changing food formulations to make them more palatable, pre-cooking foods to make them more convenient, packaging foods in small quantities to make them "child size", etc. The value chain also has the potential to reformulate products to improve the nutrition of children and adolescents (e.g., reducing *trans* fats), as well (FAO, 2013). Making sure that the food value chain aligns with goals to secure healthy diets for children and adolescents is essential.

4.2.3. Natural resources management

Environmental concerns and sustainability are ever more visible in the food system. In the past, expanding food production to meet the needs of world came at a cost to the natural environment (FAO, 2017). Furthermore, increased incidences of extreme weather events and climate-related shocks have led to reductions in crop yields and micronutrient content (Myers et al., 2017). Climate-related shocks also make communities in low-income settings vulnerable due to volatility in crop production and food prices (FAO, 2017). These communities already face severe difficulties in providing diverse diets to their children (FAO, 2017). According to the 2019 State of World's Children Report, only 1 in 5 children between the age of 6 and 23 months in low-income households and rural areas receive a diverse diet (UNICEF, 2019). Climate-related shocks further exacerbate the prevalence of poor diets amongst children living in these communities. In addition, climate-related shocks, such as flooding, have been known to expose children to a higher risk of waterborne diseases (UNICEF, 2019). All of these factors influence the ability of today's children, adolescents, and their caregivers (as well as future generations) to secure diets that align with children's and adolescents' nutritional needs.

4.2.4. Agricultural research and development

Historically, public research priorities have focused on increasing investments in enhancing productivity and yields of staple crops (cereals, roots, tubers, etc.) and cash crops (cotton, coffee, etc.) (Global Panel, 2014). This has led to the reduction in prices of staple foods, and improved their availability and affordability, in comparison to nutrient-rich foods (Global Panel, 2014). In addition to production diversification, research innovations that improve levels of nutrients in

staple crops, such as biofortification, to improve levels of nutrients in staple cops have the potential of reducing the micronutrient gap, including gaps in the diets of children and adolescents (Global Panel, 2014). Part of the solution to improving affordability and availability of nutrient-rich commodities for children, adolescents and their households requires greater research investment, political support, nutrition-sensitive food and agricultural policies, and producer buy-in for increasing the production of non-staple foods.

4.3. Food environments

Food environments refer to the physical, economic, political and socio-cultural contexts through which consumers interact with food systems to purchase, prepare and consume food (HLPE, 2017). Food environments are described as the interface between food systems and diets (FAO, 2016). The concept of food environments was developed by researchers focused on the rise in obesity and diet-related non-communicable diseases in high-income countries (Turner et al., 2018; Herforth and Ahmed, 2015; HLPE, 2017). However, the concept holds relevance for low- and middle-income countries as well, where the multiple burdens of malnutrition (or the coexisting burdens of undernutrition, overweight and obesity, and micronutrient deficiencies) are on the rise. The concept builds on the understanding that health behaviors are shaped by both inter-personal and environmental factors.

Drawing from Turner et al. (2018), we identify two domains for food environments: external and personal, each characterized by influencers that allow policymakers to shape the respective domains such that they enhance access and availability, affordability and costs, and consumption of safe, nutritious and healthy food for children and adolescents.

4.3.1. External food environments and influencers

External food environments are physical spaces where consumers interact with food systems. They reflect aspects related to availability, price, quality and safety, and the marketing and regulation of food (Supplementary Materials, Figure S.3). External food environments for children and adolescents include but are not limited to: school canteens, sports facilities, shopping malls, supermarkets, retail markets and street food carts, and other places where children, adolescents, and their caregivers interface with food.

4.3.1.1. Availability and accessibility of food. For most consumers, markets and retail food outlets are the main sources of food acquisition. This trend is becoming increasingly common across the rural-urban continuum as rural populations also rely on markets for their food consumption (Tschirley et al., 2015). The presence of and proximity to formal and informal markets informs the foods that are available to children and adolescents. Socio-economic status of populations also informs the types of external food environments children, adolescents, and their caregivers are exposed to. For instance, the built food environments in high-income settings are more likely to have easy access to formal markets whereas low-income settings are more often characterized by informal markets (HLPE, 2017; Downs et al., 2020). The types and quality of foods available in these different markets varies (Downs et al., 2020).

Children and adolescents often encounter external food environments that do not support nutritious and healthy diets. Foods available from street vendors, school canteens and small retail outlets are commonly full of foods high in saturated and trans fats, sugar and sodium (e.g., carbonated drinks, snacks, cookies, etc.), and they often stock few nutritious foods which tend to be more perishable and less in-demand (UNICEF, 2019). Many of these less-healthy food options foods are often advertised and marketed in ways that influence children's and adolescents' desire for those foods (Fox & Timmer, under for this issue). The school food environment, including within and around schools, also does not lend itself to healthy decisions (Barquera et al., 2018; Hernandez-Barrera et al., 2016). When, children and adolescents lack nutritious foods in their external food environments, and are faced with foods that are suboptimal or even damaging instead, it is challenging to achieve goals for children's and adolescents' diets.

4.3.1.2. Price of food. The price of food is also an important consideration in the external food environments. The price of foods is usually determined by retailers, who set prices, schedule promotions, etc., giving consumers (and their children and adolescents) limited control. In addition, the price of certain foods can make them unattainable to vulnerable populations such as children and adolescents. The higher cost of nutritious foods, particularly in low-income settings, is well-documented (Green et al., 2013; Headey and Alderman, 2019; FAO et al, 2020). Nutritious foods recommended to incorporate into the diets of children and adolescents, such as animal-sourced foods and fortified infant cereals, tend to be expensive, especially in comparison to the relative cost of non-cereal foods in high-income countries (Headey and Alderman, 2019). This has significant implications for the types of foods incorporated into the diets of children and adolescents.

4.3.1.3. Food quality and safety. The external food environment is also characterized by concerns about food quality and safety. This is of particular concern to young children and adolescents. Typically, food quality and safety standards exist in most places around the world (Delia, 2015). However, in many low- and middle-income settings they are not adhered to as there are limited monitoring or accountability mechanisms (HLPE, 2017). In a bid to make the food desirable to children and adolescents, food quality is often tampered with through addition of flavors, colors and processing (Giusti et al., 2008). The foods sold are often high in trans and saturated fat, sugar and sodium. As such, concerns pertaining to quality and food safety can have significant consequences on the health and nutrition of young children, as described above.

4.3.1.4. Marketing and regulation. To ensure that external food environments promote nutrition and health of children and adolescents, it is equally important that food marketing and labelling regulations encourage optimal dietary consumption practices. Food marketing strategies, including food promotion, branding, sponsorship and advertising, have been found to be directly linked to children's preferences, nutrition knowledge and consumption patterns (Cairns et al., 2013). Children and adolescents are also influenced by food labels and food packaging in their external food environment, such as those found in supermarkets and on cafeteria menus (Barquera et al., 2018). The use of cartoons and bright colors are often used to appeal to children, and are associated with foods of poor nutritional quality (Elliott and Truman, 2020). Labels indicating nutritional quality of foods provide a potential opportunity for selection of foods better aligned with children and adolescents' needs (Kraak and Story, 2015). However, these labels are not always easy to understand and often distort nutrition claims related to energy and content of foods, making it difficult for children, adolescents, and their caregivers to operationalize them (Correa et al., 2019; Tan, van der Beek, Kuznesof and Seal, 2016).

4.3.2. Personal food environments

In contrast to external food environments, personal food environments operate at the individual and household levels (Supplementary Materials, Figure S.4). They consist of individual and household level factors that shape children's and adolescents' diets and nutrition. These include accessibility, affordability and convenience of food to the family, and complement dimensions of availability, price, quality and safety, and marketing and regulation in the external food environments.

4.3.2.1. Accessibility of food. The ability of individuals and households to physically access retail outlets and markets is a crucial determinant of

where food is purchased. In low- and middle-income settings, children's and adolescents' access to food at the household level depends on food purchasing decisions taken by caregivers and guardians, often women. For older children and adolescents, this often includes adolescents themselves (Fox & Timmer, under review for this issue). The ability of these stakeholders to access better diets hinges on their capacity and means to reach retail outlets and markets (HLPE, 2017). Navigating food environments is considerably easier when individuals and households have access to suitable and safe means of transportation, such as public transport systems, sidewalks, personal vehicles, etc.

4.3.2.2. Affordability of food. Food affordability and purchasing power are dimensions common to food environments. Affordability of food is a function of an individual's or household's purchasing power. People in low- and middle-income countries, as well as low-income households in high-income countries, spend a higher portion of their budget on food (USDA, 2016; HLPE, 2017). This, coupled with a relatively higher prices of healthy foods, make low-income households vulnerable to food price volatility and shocks in the food system (FAO, 2018b). Interventions such as social protection schemes and social safety net programs often target affordability of foods for families by providing vouchers, cash transfers, and subsidies to reduce the relative price of foods for low-income stakeholders (Downs & Demmler, under review for this issue). However, it is essential that these programs connect to nutritional goals (UNICEF and GAIN, 2019). For instance, the Productive Safety Net Program in Ethiopia did not improve nutritional status of children until they incorporated explicit objectives related to nutrition in food baskets, public works, and behavior change communication (Berhane et al., 2017; Masters et al., 2018). There is an opportunity to better link such programs to the dietary needs of children and adolescents.

4.3.2.3. Convenience. Convenience is also a key determinant in shaping diets. In many low- and middle-income settings, women bear the greatest responsibility for food preparation, cooking, caring practices of households (HLPE, 2017). Greater participation of women in the labor force means that caregivers have limited time to procure and prepare foods. As a result, convenience foods are often prioritized. This includes decisions to frequent markets that are closer and more easily accessible, even if that comes at the expense of food quality. It also influences the selection of foods that reduce preparation and cooking time (and space), such as ready-to-eat foods, snacks, pre-cooked foods, etc. Some of these foods can compromise nutrition and well-being of children and adolescents in the household, particularly if they are ultra-processed (Pries et al., 2017). Food industry and public sector actors need to ensure that product reformulation regulations are in place to promote convenience foods that contain less sugar, salt and fats, and that are appropriate to support the nutrition of children and adolescents.

4.4. Behaviors of caregivers, children and adolescents

Behaviors of caregivers, children and adolescents (Supplementary Materials, Figure S.5) refer to intra-household dynamics, food preparation, supervision, and eating practices of children, adolescents and their caregivers. The *Innocenti* framework visualizes this element as where the external and personal food environments converge, and as a buffer between food environments and children's and adolescents' diets. Being one of the unique aspects of the framework, it elaborates the role of caregivers as 'gatekeepers' for the diets and nutrition of infants and young children, while also allowing for recognition of the autonomy of adolescents in making their own food decisions.

4.4.1. Intra-household dynamics

Intra-household dynamics, including feeding and care practices, inform the diets of children and adolescents. This includes dynamics of who receives what and when — for instance, girls being fed last and least (Christian and Smith, 2018) — as well as who has decision-making power and control over resources. These are gendered, and women's relative decision-making power is often positively associated with their children's nutritional status (Richards et al., 2013). This also impacts the role of adolescent girls who are married and who might have children, as they are responsible for the food and nutrition needs of their households, but might have control over resources or bargaining power. Improving gender equity in nutrition and health programming through empowerment activities, social protection, financial inclusion, etc. (Richards et al., 2013), can have a positive impact on children's and adolescents' diets.

Most importantly, though, are the dynamics between children and adolescents with other members of their households. Specifically, as children and adolescents get older, their relationship and reliance on caregivers changes. Caregivers are important gatekeepers for the diets of young children (Fox & Timmer, under review for this issue). They are responsible for the purchase, preparation, cooking and storage of food, and are an important determinant of the eating behaviors of young children. However, as children get older, they have more autonomy. Adolescents act as caregivers in cases where they supervise food consumption and eating practices of younger siblings or household members. They are also active decision-makers in determining the foods they consume as they do not always rely on their caregiver or other gatekeeper to procure, prepare and provide food (Fox & Timmer, under review for this issue). Therefore, age-specific intra-household dynamics are an important consideration in interventions that aim to improve the diets of older children and adolescents.

4.4.2. Food preparation

Food preparation also influences children's and adolescents' diets, and directly feeds back to food choices in the food environment. Considerations related to cooking skills (Martins et al., 2020), cooking equipment and space to prepare and store foods (Pelto & Armar-Klemesu, 2016), and time available to prepare foods (Jaacks et al., 2017; UNICEF, 2019), all have an influence on the types of foods that are prepared for and consumed by children and adolescents. For instance, a mother may select a food that is convenient and packaged for children, that she knows her child will eat, rather than preparing whole foods, given that it would result in less time and effort to prepare and feed if she has other strains on her time (Sharma et al., 2019). As such, food preparation decisions can be closely linked to desirability and acceptability of foods. Convenience and food preparation considerations also drive adolescents' food decisions (WFP, 2018).

4.4.3. Desirability and acceptability of food

Desirability and acceptability of food, including taste preferences, reflect some of the most important drivers of food choice, particularly among children and adolescents (WFP, 2018). Taste preferences can be both biological and conditioned (Fox & Timmer, under review for this issue). The perceived taste preferences of children can influence the foods prepared and provided by caregivers (Pries et al., 2017; Pelto and Armar-Klemesu, 2011), and also inform the foods selected by adolescents. Desirability and acceptability of foods are often directly linked to social and cultural norms. They are heavily influenced by marketing and advertising in the external food environment. They can also be influenced by modelling of older siblings, caregivers, and other role models within or outside of the household, as well as by peers. Peers play an extremely important role on food preferences of older adolescents, but can also influence the preferences of young children, as well (WFP, 2018; Fox & Timmer, under review for this issue; Lafraire et al., 2016).

4.4.4. Eating patterns and appetite

Eating patterns and appetite of children and adolescents are influenced by various factors, such as physical activity, routines, taste preferences and social aspects of eating. Dietary patterns include the types of foods consumed, the diversity of foods consumed, as well as the

frequency and patterns of intake, which are often informed by nutrition education and counseling (but also from prior experience and cultural norms). For children, dietary patterns are often decided by their caregivers and by the institutions they engage with, such as schools. Whereas, adolescents' dietary patterns might be less structured, and are often characterized by skipping breakfast, irregular meals, and snacking (Keats et al., 2018). Appetite and dietary needs are also influenced by other factors, including physical activity and health status, which can also influence energy balance and adequacy of children's and adolescents' diets.

4.5. Interactions

Employing a systems approach involves analyzing the system as an interplay of subsystems through feedback loops (Ericksen, 2008; Bene et al., 2019a). One of the key features of the *Innocenti* framework are interactions between multiple determinants of the food system (Supplementary Materials, Figure S.6). These interactions are represented by arrows that highlight feedback loops and reflect the dynamic nature of food systems.

For instance, the supply chain drives what is consumed. Crop failures due to climatic disasters that result in food price volatility, or inadequate infrastructure to get foods to markets, can influence the ability of parents to access and afford nutritious foods for their children (Choudhury et al., 2019). Supply side actors along the food chain also look to consumer trends and preferences to determine the market demand for their goods. Parents who rely on external food environments to purchase and procure food for their families send signals to actors in food supply chains on their food preferences and dietary patterns, thereby shaping food production and availability. It is thus critical to consider the interactions and feedback loops between and among food system drivers, determinants and influencers when designing policies and programs that aim to improve diets of children and adolescents. Attention to these interactions is important as effects in one part of the system can amplify or dampen effects in another, and following this dynamic process helps to anticipate unintended consequences in the evolving food system (Pinstrup-Andersen and Watson, 2011; Tendall et al., 2015).

4.6. Diets of children and adolescents

While food systems can be transformed to achieve multiple outcomes, the primary outcome ought to be to improve the quality of diets, especially for vulnerable groups. Although the nutritional status and diets of children and adolescents are also influenced by other systems, such as health systems, water systems, education systems, etc., the *Innocenti* Framework locates diets of children and adolescents as one of the main goals of food systems. Diets entail the quantity, frequency, quality, and mix of different foods that children and adolescents consume. As demonstrated by the different elements of the Innocenti Framework, actors across the food system, including children and adolescents themselves, play a role in shaping the influencers of food systems determinants to yield better diets for children and adolescents, globally. Children's and adolescents' diets are discussed in more detail in other papers of this special issue (Kupka et al, 2020; Hollis et al., forthcoming in this special issue).

5. Discussion and conclusion

The proposed conceptual framework provides a comprehensive overview of how food systems influence the diets of children and adolescents. It provides two main contributions to the literature. First, it aims to bridge the recent discussion on food systems with the literature on child and adolescent nutrition. This is important as the literature on child and adolescent nutrition has yet to elaborate food systems-related elements and processes which drive dietary outcomes of children and adolescents. Second, the framework also allows for policymakers and practitioners to conceptualize linkages between different elements of the food system and diets of children and adolescents. These stakeholders are often challenged to design and implement policies that not only ensure higher quantity of food but also increase the availability and affordability of nutrient-rich foods (Global Panel, 2014). The framework, thus, aims to provide a broader understanding of the linkages between food systems and children and adolescents' diets, and at the same time presents an opportunity for policy makers and practitioners to think through the elements and interactions which underpin these linkages when design and implementing policies. In the framework, the 'influencers' for each element of the framework provide potential entry points for policymakers and practitioners, as well the actors across the food system, to shape more nutrition-focused food systems for children and adolescents.

The framework, however, is not without limitations. Although the different elements of the food system are linked together through a series of arrows, it does not fully capture the dynamic nature of the food system, the feedback between those arrows, nor aspects of the food system that might amplify or attenuate the ability of children and adolescents to achieve optimal diets. However, capturing such complexity would make it difficult to interpret and visualize the framework. Additionally, how different determinants in the system feedback and actually inform other determinants is not well illuminated. In part, this is because it is difficult to capture the multiple impacts that changes in the system might have, but also because they might not be measured well or at all. Our final limitation is related to prioritizing action. Although the influencers provide 'entry points' for adjusting the food system, the framework itself does not allow for identification or prioritization of actions. This would require more in-depth analysis of specific food systems, to best identify the most appropriate and context-relevant actions.

Despite these limitations, the framework is meant to provide multiple-outcome accountability across the food system. While diets and health are prioritized for the purposes of this framing, food systems have other outcomes – environmental, social and economic dimensions – that in turn impact health and nutrition. These multiple outcomes need to be accounted for when conceptualizing and operationalizing frameworks to capture synergies and trade-offs. There needs to be greater emphasis on the governance of food systems and accountability mechanisms of different food systems actors, especially towards analyzing the roles and responsibilities of different actors (formal, informal, public and private) in reaching children and adolescents with nutritious, safe and affordable food (Kraak et al, 2014; Swinburn et al., 2019).

Disclaimers

Ahmed Raza is a staff member of FAO. The opinions and statements in this article are his own and do not reflect official FAO policies. Roland Kupka and Nita Dalmiya are UNICEF staff members. The opinions and statements in this article are those of the authors and may not reflect official UNICEF policies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2020.100436.

References

Augustin, M.A., Riley, M., Stockmann, R., Bennett, L., Kahl, L., Lockett, T., Cobiac, L., 2016. Role of food processing in food and nutrition security. Trends Food Sci. Technol. 56, 115–125.

Barquera, S., Hernandez-Barrera, L., Rothenberg, S.J., Cifuentes, E., 2018. The obesogenic environment around elementary schools: food and beverage marketing to children in two Mexican cities. BMC Publ. Health 18, 461.

Bene, C., Oosterveer, P., Lamotte, L., Brouwer, I., de Haan, S., Prager, S., Khoury, C., 2019a. When food systems meet sustainability – current narratives and implications for actions. World Development 113, 116–130.

Bene, C., Prager, S., Achicanoy, H., Toro, P., Lamotte, L., Cedrez, C., Mapes, B., 2019b. Understanding food systems drivers: a critical review of the literature. Global Food Security 149–159.

Berhane, G., Hoddinott, J., Kumar, N., 2017. The Impact of Ethiopia's Productive Safety Net Programme on the Nutritional Status of Children: 2008-2012. International Food Policy Research Institute.

Cairns, G., Angus, K., Hastings, G., Caraher, M., 2013. Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. Appetite 62, 209–215.

Choudhury, S., Heady, D.D., Masters, W.A., 2019. First foods: diet quality among infants aged 6-23 months in 42 countries. Food Pol. 88.

Christian, P., Smith, E., 2018. Adolescent undernutrition: global burden, physiology, and nutritional risks. Ann. Nutr. Metab. 72, 316–328.

Correa, T., Fierro, C., Reyes, M., Dillman Carpentier, F., Taillie, L., Corvalan, C., 2019. Responses to the Chilean law of food labeling and advertising: exploring knowledge, perceptions and behaviors of mothers of young children. Int. J. Behav. Nutr. Phys. Activ. 16 (1), 21-21.

Delia, G., 2015. Food safety in low and middle income countries. Int. J. Environ. Res. Publ. Health 12 (9), 10490–10507.

Downs, S., Demmler, K., 2020. Food environment interventions targeting children and adolescents: a structured review. Global Food Security (under review for this issue).

Downs, S., Fanzo, J., 2016. Managing value chains for improved nutrition. Good Nutrition: Perspectives for the 21st Century. Karger, New York, pp. 45–59.

Downs, S., Ahmed, S., Fanzo, J., Herforth, A., 2020. Food environment typology: advancing an expanded definition, framework, and methodological approach for improved characterization of wild, cultivated, and built food environments toward sustainable diets. Foods 9 (4), 532.

Elliott, C., Truman, E., 2020. The power of packaging: a scoping review and assessment of child-targeted food packaging. Nutrients 12 (4), 958.

Ericksen, P.J., 2008. Conceptualizing food systems for global environmental change research. Global Environ. Change 18 (1), 234–245.

Fanzo, J., Downs, S., Marshall, Q., de Pee, S., Bloem, M., 2017. Value chain focus on food and nutrition security. In: de Pee, S., Taren, D., Bloem, M. (Eds.), Nutrition and Health in a Developing World. Humana Press, Cham, pp. 753–770.

FAO, 2013. The state of food and agriculture. Food Systems for Better Nutrition. FAO, Rome.

FAO, 2016. Influencing Food Environments for Healthy Diets. FAO, Rome.

FAO, 2017. The Future of Food and Agriculture – Trends and Challenges. FAO, Rome.

FAO, 2018a. Sustainable Food Systems. Concept and Framework. FAO, Rome.

FAO, 2018b. The State of Food Security and Nutrition in the World 2018. FAO, Rome, Italy.

FAO, 2019. The State of Food and Agriculture 2019. FAO, Rome, Italy.

FAO, IFAD, UNICEF, WFP, WHO, 2020. The State of Food Security and Nutrition in the World 2020 (SOFI 2020). FAO, Rome.

Fox, E., Timmer, A., 2020. Children's and adolescents' characteristics and interactions with the food system. Global Food Security (under review for this issue).

Gelli, A., Hawkes, C., Donovan, J., Harris, J., Allen, S., De Brauw, A., Ryckembusch, D., 2015. Value chains and nutrition: a framework to support the identification, design, and evaluation of interventions. IFPRI.

Giusti, A.M., Bignetti, E., Cannella, C., 2008. Exploring new frontiers in total food quality definition and assessment: from chemical to neurochemical properties. Food Bioprocess Technol. 1 (2), 130.

Global Panel, 2014. How Can Agriculture and Food System Policies Improve Nutrition? Technical Brief. Global Panel on Agriculture and Food Systems for Nutrition, London, UK.

Global Panel, 2018. Preventing Nutrient Loss and Waste across the Food System: Policy Actions for High-Quality Diets. Policy Brief No. 12. Global Panel on Agriculture and Food Systems for Nutrition, London, UK.

Gong, Y., Cardwell, K., Hounsa, A., Egal, S., Turner, P., Hall, A., Wild, C., 2002. Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: a cross sectional study. BMJ 325 (7354), 20–21.

Green, R., Cornelsen, L., Dangour, A.D., Turner, R., Shankar, B., Mazzocchi, M., Smith, R. D., 2013. The effect of rising food prices on food consumption: systematic review with meta-regression. BMJ 346.

Guerrant, R.L., Oriá, R.B., Moore, S.R., Oriá, M.O., Lima, A.A., 2008. Malnutrition as an enteric infectious disease with long-term effects on child development. Nutr. Rev. 66 (9), 487–505.

Hawkes, C., Ruel, M., 2012. Value chains for nutrition. In: Fan, S., Pandya-Lorch, R. (Eds.), Reshaping Agriculture for Nutrition and Health. IFPRI, Washington, D.C., pp. 73–82

Headey, D., Alderman, H., 2019. The relative caloric prices of healthy and unhealthy foods differ systematically across income levels and continents. J. Nutr. Community and International Nutrition 149.

Herforth, A., Ahmed, S., 2015. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. Food Security 7 pages505–520.

Hernandez-Barrera, L., Rothenberg, S.J., Barquera, S., 2016. The toxic food environment around elementary schools and childhood obesity in Mexican cities. Am. J. Prev. Med. 51 (Issue 2), P264–P270.

Herrero, M., Thornton, P., Power, B., Bogard, J., Remans, R., Fritz, S., Wijk, v., 2017. Farming and the geography of nutrient production for human use: a transdisciplinary analysis. *The Lancet*. Planetary Health 1 (Issue 1), PE33–E42.

HLPE, 2017. Nutrition and Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (CFS). CFS, Rome, Italy.

Hollis, J., Collins, C., DeClerck, F., Kheng Chai, L., McColl, K., Demaio, A., 2020. Defining healthy and sustainable diets for infants, children and adolescents. Global Food Security (forthcoming in this special issue).

ICN2, 2014. Conference outcome document: framework for action, from commitments to action. In: Second International Conference on Nutrition (ICN2). 19-21 November 2014. Rome. FAO/WHO.

IFPRI, 2012. Aflatoxin: Impact on Stunting in Children and Interventions to Reduce Exposure. International Food Policy Research Institute (IFPRI), Washington, DC.

ILO, 2017. Global Estimates of Child Labour: Results and Trends, 2012–2016. International Labour Of ce (ILO), Geneva.

Ingram, J., 2011. A food systems approach to researching food security and its interactions with global environmental change. Food Security 3 (4), 417–431.

Jaacks, L.M., Kavle, J., Perry, A., Nyaku, A., 2017. Programming maternal and child overweight and obesity in the context of undernutrition: current evidence and key considerations for low- and middle-income countries. Publ. Health Nutr. 20 (7), 1286–1296.

Juarez, F., LeGrand, T., Loyd, C.B., Singh, S., Hertrich, V., 2013. Youth migration and transitions to adulthood in developing countries. Ann. Am. Acad. Polit. Soc. Sci. 648 (1), 6–15.

Keats, E.C., Rappaport, A.I., Shah, S., Oh, C., Jain, R., Bhutta, Z.A., 2018. The dietary intake and practices of adolescent girls in low- and middle-income countries: a systematic review. Nutrients 10 (12), 1978.

Kelly, B., Vandevijvere, S., S, N., al, e., 2019. Global benchmarking of children's exposure to television advertising of unhealthy foods and beverages across 22 countries. Obes. Rev. 20 (Suppl. 2), 116–128. Suppl. 2.

Kraak, V., Story, M., 2015. Influence of food companies' brand mascots and entertainment companies' cartoon media characters on children's diet and health: a systematic review and research needs. Obes. Rev. 16 (2), 107–126.

Kraak, V.I., Swinburn, B., Lawrence, M., Harrison, P., 2014. An accountability framework to promote healthy food environments. Publ. Health Nutr. 17 (11), 2467–2483.

Kupka, R., Siekmans, K., Beal, T., 2020. The diets of children: overview of available data for children and adolescents. Global Food Security (forthcoming in this special issue).

Lafraire, J., Rioux, C., Giboreau, A., Picard, D., 2016. Food rejections in children: cognitive and social/environmental factors involved in food neophobia and picky/fussy eating behavior. Appetite 96, 347–357.

Lawrence, M., Friel, S., Wingrove, K., James, S., Candy, S., 2015. Formulating policy activities to promote healthy and sustainable diets. Publ. Health Nutr. 18 (13), 2333–2340.

Martins, C.A., Machado, P.P., Louzada, M.L., Levy, R.B., Monteiro, C.A., 2020. Parents' cooking skills confidence reduce children's consumption of ultra-processed foods. Appetite 144, 104452.

Masters, W., Rosettie, K., Kranz, S., Danaei, G., Webb, P., Mozaffarian, D., 2018. Designing programs to improve diets for maternal and child health: estimating costs and potential dietary impacts of nutrition-sensitive programs in Ethiopia, Nigeria, and India. Health Pol. Plann. 33 (4), 564–573.

Mozaffarian, D., 2016. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. Circulation 133, 187–225.

Myers, S.S., Smith, M.R., Guth, S., Golden, C.D., Vaitla, B., Mueller, N.D., Huybers, P., 2017. Climate change and global food systems: potential impacts on food security and undernutrition. Annu. Rev. Publ. Health 38, 259–277.

NCD-RisC, 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2,416 population-based measurement studies in 128.9 million children, adolescents, and adults. NCD Risk Factor Collaboration (NCD-RisC). Lancet 390 (10113), 2627–2642.

Nordhagen, S., 2020. s. Evidence review: food supply chains and child and adolescent diet. Global Food Security (under review for this issue).

Pelto, G.H., Armar-Klemesu, M., 2016. Identifying interventions to help rural Kenyan mothers cope with food insecurity: results of a focused ethnographic study. Maternal & Child Nutrition.

Pelto, G., Armar-Klemesu, M., 2011. Balancing nurturance, cost and time: complementary feeding in Accra, Ghana. Matern. Child Nutr. 7 (s3), 66–81, 7(s3), 66-81.

Pinstrup-Andersen, P., Watson, D., 2011. Food Policy for Developing Countries. Cornell University Press, Ithaca.

Pries, A., Huffman, S., Champeny, M., Adhikary, I., Benjamin, M., Coly, A.N., Zehner, E., 2017. Consumption of commercially produced snack foods and sugar-sweetened beverages during the complementary feeding period in four African and Asian urban contexts. Matern. Child Nutr. 13 (Suppl 2), e12412 https://doi.org/10.1111/mcn.12412.

Richards, E., Theobald, S., George, A., Kim, J.C., Rudert, C., Jehan, K., Tolhurst, R., 2013. Going beyond the surface: gendered intra-household bargaining as a social determinant of child health and nutrition in low and middle income countries. Soc. Sci. Med. 95, 24–33.

Sharma, N., Ferguson, E.L., Upadhyay, A., Zehner, E., Filteau, S., Pries, A.M., 2019. Perceptions of commercial snack food and beverages for infant and young child feeding: a mixed-methods study among caregivers in Kathmandu Valley, Nepal. Maternal & Child Nutrition 15 (S4).

Smith, R., Kelly, B., Yeatman, H., Boyland, E., 2019. Food marketing influences children's attitudes, preferences and consumption: a systematic critical review. Nutrients 11 (4), 875. Apr 18.

Sobal, J., Khan, L.K., Bisogni, C., 1998. A conceptual model of the food and nutrition system. Soc. Sci. Med. 47 (7), 853–863.

Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R., Hovmand, P.S., 2019. The global syndemic of obesity, undernutrition and climate change: the Lancet Commission report. Lancet 393 (10173), 791–846.

Tan, K., van der Beek, E., Kuznesof, S., Seal, C., 2016. Perception and understanding of health claims on milk powder for children: a focus group study among mothers in Indonesia, Singapore and Thailand. Appetite 105, 747–757.

Temin, M., Montgomery, M.R., Engebreston, S., Baker, K.M., 2013. Girls on the Move: adolescent girls and migration in the developing world. A Girls Count Report on Adolescent Girls. Population Council.

Tendall, D.M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q.B., Six, J., 2015. Food system resilience: defining the concept. Global Food Security 6, 17–23.

Tschirley, D., Snyder, J., Dolislager, M., Reardon, T., Haggblade, S., Goeb, J., Meyer, F., 2015. Africa's unfolding diet transformation: implications for agrifood system employment. Journal of Agribusiness in Developing and Emerging Economies 5 (2), 102–136.

Turner, C., Aggarwal, A., Walls, H., Herforth, A., Drewnowski, A., Coates, J., Kadiyala, S., 2018. Concepts and critical perspectives for food environment research: a global framework with implications for action in low- and middle-income countries. Global Food Security 93–101.

UNICEF, 2018. UNICEF Global Databases. Retrieved from United Nations Children's Fund (UNICEF). Division of Research and Policy. Infant and Young Child Feeding: https://data.unicef.org/topic/nutrition/infant-and-young-child-feeding/.

UNICEF, GAIN, 2019. Food Systems for Children and Adolescents. Working Together to Secure Nutritious Diets. UNICEF, New York.

UNICEF, 2019. The state of the world's children 2019. Children, food and nutrition: growing well in a changing world. UNICEF.

UNICEF/WHO/World Bank, 2020. UNICEF/WHO/The World Bank Group Joint Child Malnutrition Estimates: Levels and Trends in Child Malnutrition: Key Findings of the 2020 Edition. United Nations Children's Fund, World Health Organization, World Bank Group.

USDA, 2016. Percent of Consumer Expenditures Spent on Food, Alcoholic Beverages, and Tobacco that Were Consumed at Home, by Selected Countries, 2015. Retrieved from USDA ERS Food Expenditure Series 2016 : https://www.ers.usda.gov/data-products/food-expenditures.aspx.

von Boekel, M., Fogliano, V., Pellegrini, M., Stanton, C., Scholz, G., Lalljie, S., Eisenbrand, G., 2010. A review on the beneficial aspects of food processing. Mol. Nutr. Food Res. 54 (9), 1215–1247.

WFP, 2018. Bridging the Gap: Engaging Adolescents for Nutrition, Health and Sustainable Development. World Food Programme.

WHO, 2018. Healthy diet. Retrieved from Key Facts: https://www.who.int/news-room/fact-sheets/detail/healthy-diet.