
Impact of the food environment on diet-related health outcomes in school-age children and adolescents in low- and middle-income countries: a systematic review

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Background

Current estimates indicate that some form of malnutrition (undernutrition, overweight or obesity, and poor dietary habits) affects one in three people worldwide (IFPRI, 2016), and the 2016 Global Burden of Disease study has placed poor dietary habits as one of the leading risk factors for mortality globally (Collaborators GBD, 2017). Over the past decade, there has been great momentum around addressing malnutrition in all its forms and commitment to actions that can accelerate progress to reduce its associated burden of morbidity and mortality. In 2012, the World Health Assembly (WHA) adopted the 2025 Global Targets for Maternal, Infant and Young Child Nutrition and in 2013, WHA adopted targets for non-communicable diseases (NCDs), including several nutrition-relevant targets (IFPRI, 2016). More recently, the United Nations elevated its efforts through a global declaration of 17 Sustainable Development Goals (SDGs), where at least 12 of the 17 goals feature indicators relevant to nutrition. In line with these targets, the decade of 2016-25 has been declared the Decade of Action on Nutrition (IFPRI, 2016).

At the forefront of malnutrition and poor dietary intake is the food system. Rapid globalization and urbanization in low- and middle- income countries (LMICs) have incited major changes to the landscape of food, whereby food environments outside of the home, especially urban food environments, have become increasingly obesogenic at an economical price. This has consequently affected food preferences, dietary patterns, and habits, leading to a population-wide nutrition transition that is also evident in school-age children and adolescents (IFPRI, 2017).

Borrowing from the early work of Penchansky and Thomas, the food environment has been conceptualized to possess five dimensions that impact food choice and dietary intake: availability, spatial accessibility, affordability, accommodation and acceptability. Others have proposed a food environment model with four nutrition environments, including the community, consumer, organizational and information environments (Glanz, Sallis, Saelens and Frank, 2005). In 2012, a global network of public-interest organizations and researchers aiming to monitor, benchmark and support public and private sector actions to create healthy food environments and reduce obesity and non-communicable diseases (NCDs) was established. This network, named The International Network for Food and Obesity/Non-

Communicable Diseases Research, Monitoring and Action Support (INFORMAS), defines the food environment as ‘the collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people’s food and beverage choices and nutritional status’ (Swinburn et al., 2013).

The synthesis and appraisal of current literature on food environment interventions and their impact on diet-related health outcomes in the context of school-age children and adolescents in LMICs will help to validate a contextually-relevant conceptual framework for school-age children and adolescents. This will ensure our subsequent analyses are grounded in a thorough understanding of the characteristics of food environments that are specific to LMICs. It is important to note that there are several proposed conceptual frameworks with a global lens available from Health Canada, the High Level Panel of Experts for Food Security and Nutrition, and the Global Panel on Agriculture and Food Systems for Nutrition (see Appendix 1) (Health Canada, 2013; Development Initiatives, 2017; HPLE, 2017).

Figure 1 (below) is a visual depiction of the food environment in the context of the greater food system, while Figure 2 is our proposed conceptual framework of the food environment proper. Importantly, Figures 1 and 2 are not definitive maps of the existing evidence. Rather, they are proposed ‘working hypotheses’ to help guide the implementation of this review. Figure 1 assists in understanding the boundaries and limitations of the food environment in order to identify outcomes and measurements within and outside the scope of our review. It is believed that the food environment is a complex adaptive system, whereby there are various industries and actors which operate interdependently and adaptively within the food environment, and their interaction is often shaped through spatial and temporal complexity. As seen in Figure 2, it is believed that the food environment innately possesses six dimensions including *procurement* (i.e. food availability, food assistance, national food supply), *accessibility* (i.e. proximity and density), *promotion* (i.e. media and advertising), *price* (i.e. cost and affordability), *purchasing* (i.e. vendor sales, purchasing power, purchasing behaviours, preferred purchasing location, consumer demographics), and *policy* (i.e. legislation and regulations in relation to food labelling, food assistance and food marketing). These dimensions and their associated measures are useful for understanding the food environment, especially in urbanized settings of LMICs. As well, the intersection of these dimensions can occur at a national, regional or community scale, and often directly or indirectly involve primary and secondary sectors such as agriculture, food manufacturing and food processing. The food environment can be further subdivided into micro-food environments, namely, consumer, institutional (school or workplace) and household environments, where each environment mutually influences one another, especially in terms of knowledge translation and transfer of food and nutrition. Understanding direct and

indirect interactions between micro-food environments are outside of the scope of this review.

It is hypothesized that Figure 2 exists within a wider conceptual framework that links to dietary intake in school-age children and adolescents in LMICs. There are several additional factors, including individual preferences, knowledge, awareness and attitudes towards food, cooking practices, and quantity of consumption that will impact dietary intake and ultimately diet-related health outcomes.

Understanding how the food environment impacts diet-related health outcomes in school-age children and adolescents in low- and middle- income countries (LMICs) is critical for offering strategic recommendations for food environment improvement, encouraging advocacy, improving research within this field, and the ultimate goal to improve health outcomes. Knowledge products from this work will help to inform a set of robust monitoring indicators that will enable better quantification of food environment risk factors for malnutrition in school-age children and adolescents in LMICs. From this, we can better understand how to address these risk factors and improve the food environment through programs and policies targeted for school-age children and adolescents in LMICs.

Figure 1. Hypothesized Conceptual Framework of the Food System

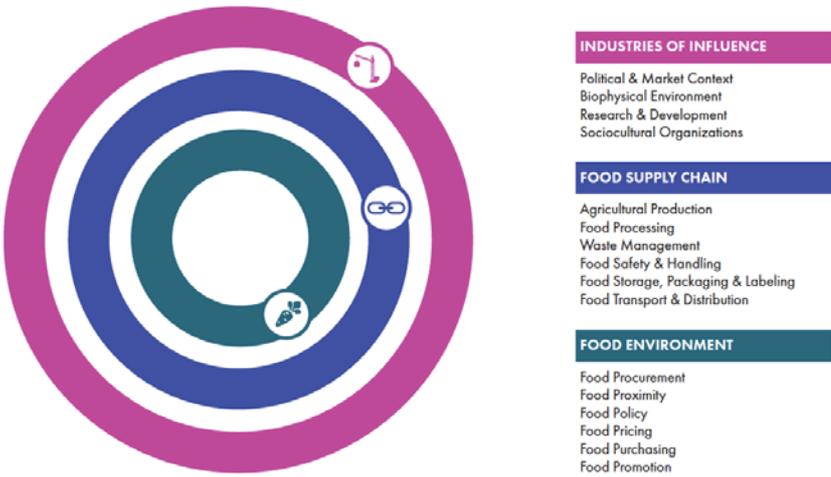
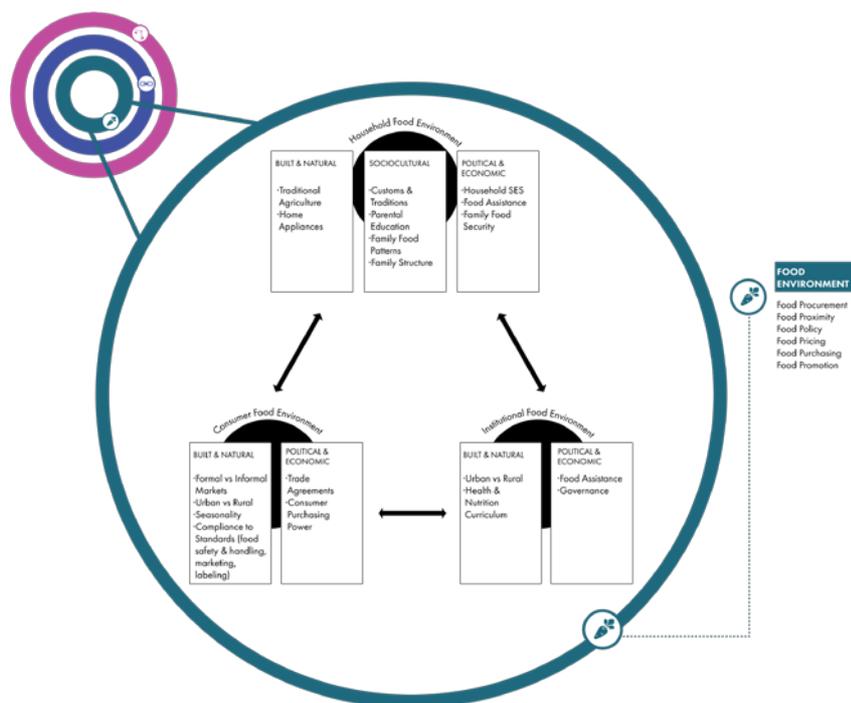


Figure 2. Hypothesized Conceptual Framework of the Food Environment



Policy relevance

Several initiatives and policies relating to the food environment have made headway at the international and national level. A global movement to reduce the marketing of unhealthy foods to children began in 2003 by the World Health Organization (WHO). In 2010, WHO Member States agreed to a set of recommendations to combat childhood obesity. Since then, the International Obesity Task Force, has responded by proposing international standards to specify unhealthy food marketing to children, and the Political Declaration of the UN High-Level Meeting on the Prevention and Control of Non-Communicable Diseases (September 2011) has corroborated this recommended action on marketing and advertising to children. At the country-level, several countries, including some LMICs, have ratified policies related to sugar/soda taxes (for example, Mexico), food labelling and food provision, especially in school food environments.

Our review hopes to give insight into effective food environment interventions that could see a policy implications related to regulating home, community, and school food environments.

Objectives

Our objective for this review is to synthesize and assess current literature on the effects of food environment interventions on diet-related health outcomes in school-age children and adolescents in LMICs.

Additionally, we hope to explore variation in effects according to settings, context, population characteristics, social, economic and political factors, as well as how interventions are delivered and who delivers them.

Existing Reviews

To date, there are no standardized measures of the food environment in LMICs and little good-quality evidence to link the food environment to dietary intake and diet-related health outcomes in school-age children and adolescents in LMICs. In fact, a lack of consistency in the definition of a food environment presents challenges in synthesizing data. To our knowledge, there are no systematic reviews on this topic that have been conducted or are in progress in LMICs.

Related literature and systematic reviews have been focused in high-income countries. These reviews have examined:

- Food environment methodology (McKinnon et al. 2009; Glanz, 2009; Charreire et al., 2010; Kelly, Floor and Yeatman, 2011; Gustafson, Hankins and Jilcott, 2012; Caspi, Sorensen, Subramanian and Kawachi, 2012; Lytle and Sokol, 2017);
- Food environment interventions (Black, D'Onise, McDermott, Vally and O'Dea, 2017; Townshend and Lake, 2017; Penney, Brown, Maguire, Kuhn and Monsivais, 2015);
- Food environment intervention cost-effectiveness (McKinnon, Siddiqi, Chaloupka, Mancino, Prasad, 2016);
- Food environment exposures in association with dietary intake, dietary behaviour and or diet-related health outcomes (Holsten, 2008; Cassagrande, Whitt-Glover, Lancaster, Odoms-Young and Gary, 2009; Dunton, Kaplan, Wolch, Jerrett and Reynolds, 2009; Feng, Glass, Curriero, Stewart and Schwartz, 2009; Osei-Assibey et al., 2012; Williams et al., 2013; Kirkpatrick et al., 2014; Drieseen, Cameron, Thornton, Lai and Barnett, 2014; Engler-Stringer, Le, Gerrard and Muhajarine, 2014; Williams et al., 2014; Martin, Ogilvie and Suhrcke, 2014; Gamba, Schuchter, Rutt and Seto, 2015; Lenardson, Hansen and Hartley, 2015; Roy, Kelly, Rangan and Allman-Farinelli, 2015; Cetateanu and Jones, 2016; Cobb et al., 2015; Pineda and Mindell, 2016; Olstad et al., 2017).

On-going reviews (registered with PROSPERO) are also focused in high-income countries (Pacheco, Balan, Archibald, Grant and Skafida, 2017; Sisnowski, Street and Merlin, 2015; Almiron-Roig, Beasley, Stevens, Bryant, Kirk, 2014)

It is also worth noting the childhood obesity intervention reviews conducted by Cochrane. A total of seven reviews have been published, one prevention-focused (Waters et al., 2011) and six which are curative-focused through six approaches including surgery, drugs, parent-only interventions, diet, physical activity, and behavioural interventions for young children (aged 0 to 6 years), schoolchildren (aged 6 to 11 years) and adolescents (aged 12 to 17 years) (Mead et al., 2017; Mead et al., 2016; Colquitt et al., 2016; Al-Khudairy et al., 2017; Loverman et al., 2015; Ells et al., 2015). Our review differs from the three relevant Cochrane reviews (Waters et al., 2011; Mead et al., 2017 and Al-Khudairy et al., 2017) in that we will include both preventive and curative environmental interventions at the food environment level for multiple diet-related health outcomes, including but not limited to obesity. Moreover, our inclusion criteria contrasts that of the Cochrane reviews in that we do not have a minimum intervention time, we will not include dietary intake interventions alone or physical activity interventions alone. Finally, in the meta-analysis of all three reviews, the majority of studies were conducted in high-income settings, whereas our review is focused in LMIC settings.

Intervention

With global increases in obesity prevalence, especially in low- and middle- income countries, there are a variety of interventions that have been categorized and implemented with intent to improve the food environment (Lobstein, 2015). These interventions are often best evaluated in randomized controlled trials (RCTs) whereby the efficacy and degree to which interventions produce an impact of change are tested under optimally controlled conditions, minimizing bias and confounding factors (Marchand, 2011). However, there are interventions (e.g. policy-based or food-retail interventions) that cannot be so rigorously randomized and controlled, and as such, the RCT is not an appropriate study design. In these cases, natural experimental and quasi-experimental designs are used for impact evaluation (Taillie, 2017).

Natural and quasi-experimental studies evaluate a change or exposure that is outside the control of the researchers, proving more difficult to manipulate the exposure and randomize participants into intervention and control groups (Craig, 2011). These limitations present several challenges, such as ensuring strong internal and external validity, minimizing potential unmeasured confounders, mitigating pre-existing baseline differences in the outcome between groups, and being flexible with uncontrolled timing and seasonality, etc. Despite this, natural and quasi-experimental studies offer greater generalizability than RCTs. As well, they provide critical insight and information about real-world settings, such as how feasible the implementation of an intervention is in situations where a considerable lack of control exists (Taillie, 2017).

Among food environment interventions, there are multiple classifications. One approach distinguishes food environment interventions as preventive or curative-based (Swinburn, 2002; Harvard, 2017). Preventive interventions intend to improve the food environment by minimizing exposure to unhealthy environments (e.g. limiting unhealthy food options in school cafeterias) or by preventing and mitigating poor health with proactive strategies (e.g. with programs which minimize advertising of unhealthy food and) (Harvard, 2017). Curative interventions involve long-term strategies to improve population health, such as reducing the population's prevalence of obesity. Examples of these interventions include public education campaigns and policy interventions on taxation and television advertising of unhealthy foods (Swinburn, 2002).

Interventions can also be defined as environmental or behavioural (Roberto, 2015; WCRFI, 2017), whereby environmental interventions target the various spheres of an individual's environment that influence their choice in food and beverages. These include the built and natural physical environments, legal and political environments, socio-economic, and cultural environments. Examples of environmental interventions include school-feeding programs or policies that incentivize vendors to provide healthier retail environments. Behavioural interventions place a greater focus on the individual, targeting their knowledge, attitudes, perceptions, preferences, and abilities in food and beverage choice and consumption patterns. Several theories and models of behavioural change such as the theory of planned behavior, diffusion of innovation theory, the social cognitive theory, and the health belief model, offer insight into the behavioural relationship between food environment interventions and diet-related health outcomes. Behavioural interventions include nutrition counselling and education for educators and students, physical activity programs, and public awareness campaigns (WCRFI, 2017). As well, it is acknowledged that overlap in interventional effects may occur whereby interventions, such as nutritional labelling policies, may alter both the environment and behaviour of the individual or consumer. Likewise, there may be instances where interventions could be categorized as both preventive (and or curative-based), as well as environmental (and or behavioural).

This behaviour-environmental approach is consistent with other models and frameworks designed to identify and categorize distinct areas of policy and intervention actions. Similarly, the NOURISHING framework, created by the World Cancer Research Fund International (WCRFI) identifies ten specific areas where policy and interventions can be used to improve food environments (WCRFI, 2017; Hawkes, 2013). While designed to be globally applicable, WCRFI recognizes that the framework's key areas would need to be adapted to the specific context and population of different countries. The framework's ten areas are divided into seven environmental and policy areas, and three behavioural areas (WCRFI, 2017; Hawkes, 2013).

Environmental & Policy:

- Nutritional labelling standards and regulations
- Interventions and policies that modify the availability and accessibility of health food in public and other settings
- Economic tools to address food affordability and purchasing incentives
- Food advertisement regulation
- Nutritional quality of the whole food supply
- Incentives and regulations to create healthier retail and food service environments
- Interventions and policies that influence the supply chain and actions across all sectors

Behavioural:

- Public awareness campaigns on food and nutrition
- Nutritional counselling in health care settings
- Nutritional education and skills building

Further, interventions can be classified by their level of implementation. Swinburn and Egger (2002) suggest that interventions can be categorized into two main groups. A 'settings-based' intervention would focus primarily on micro-environments (micro-level) such as schools, workplaces and neighbourhoods, whereas 'sector-based' interventions would target macro- and meso-level environments such as the food industry and national supply chain (Swinburn, 2002). A simplified logic model from the CDC distinguishes four levels of implementation: policy-level, community-level, organizational-level and the individual-level. The policy-level includes interventions that influence legislation and policies that have a macro-level exposure, such as food safety laws and supply chain regulation. Community-level interventions focus on increasing the awareness of the general population, while the organizational-level interventions are intended to influence organizations and systems such as health-care systems, industry players and community-based organizations. Lastly, the individual-level defines interventions as those that improve and enhance the knowledge, skills, attitudes, abilities and preferences of the individual (CDC, 2013).

In this review, interventions from all categories and levels of implementation will be included, with the exception of those that are solely behaviour-focused at an individual-level (i.e nutrition education/counselling), diet-related such as supplementation, calorie-restriction, and intake of special food items (e.g. gluten-free, organic, GMO, high-fat, high-sugar), and physical activity-focused. These interventions do not fall within the scope of our review as our main focus is on interventions that pertain to the food environment. However, in cases where a two-armed parallel RCT is testing a multi-component intervention (diet-

and or physical activity-based intervention in combination with a food environment intervention) it will be included and analysed separately from single-component intervention studies. Additionally, where an intervention includes behavioural components in addition to environmental components, this will be clearly documented.

Finally, we acknowledge that conceptually food composition and quality in terms of food safety (including food handling, sanitation and hygiene) and food fortification at the industrial, retail and household levels are important mediators in the relationship between the food environment and diet-related health outcomes. However, these specific aspects are outside of the scope of our review.

Population

Study participants include school-age children (defined as children aged 5 to 9 completed years) and adolescents (defined as individuals aged 10 to 19 completed years) of both sexes in LMICs.

Outcomes

Food environment interventions and their impact on primary and secondary outcomes will be prioritized throughout this review.

Primary outcomes: diet-related health consequences

Primary outcomes will encompass anthropometric and diet-related health outcomes relevant to school-age children and adolescents including (see Appendix 2 for more details):

- Anthropometric outcomes
- Diet-related health outcomes

Secondary outcomes: dietary intake

Secondary outcomes will surround dietary intake including (see Appendix 2 for more details):

- Types of food, food groups consumed or score
- Food composition
- Frequency of consumption
- Quantity of consumption
- Place of consumption
- Meal patterns

Study designs

We intend to include experimental and quasi-experimental studies (randomized controlled trials, non-randomized controlled trials, interrupted-time series studies, repeated measures studies). We will exclude animal studies, observation studies and other systematic reviews (though reference lists of relevant systematic reviews will be reviewed for studies that meet our inclusion/exclusion criteria).

We will include studies reported as full text, those published as abstract only, and unpublished data. We will not impose any language restrictions.

We will consider all available published and unpublished papers, reports and grey literature that conduct a food environment intervention among school-age children and adolescents across LMICs, with a particular focus on Africa, Asia, and Latin America. Databases to be included are MEDLINE, Embase, PsycINFO, BiblioMap (EPPI-Centre database of health promotion research), TRoPHI (EPPI-Centre Trials Register of Promoting Health Interventions), 3ie and Cochrane Central Register of Controlled Trials. As well, hand-searching will be conducted within online repositories including World Obesity, eLENA (WHO e-Library of Evidence for Nutrition Actions), the International Food Policy and Research Institute (IFPRI), Food and Agriculture Organization (FAO), World Food Programme (WFP), World Health Organization Library Database (WHOLIS), INFORMAS and the National Cancer Institute's Measures of the Food Environment website (an online repository of food environment measures research).

Appendix 1

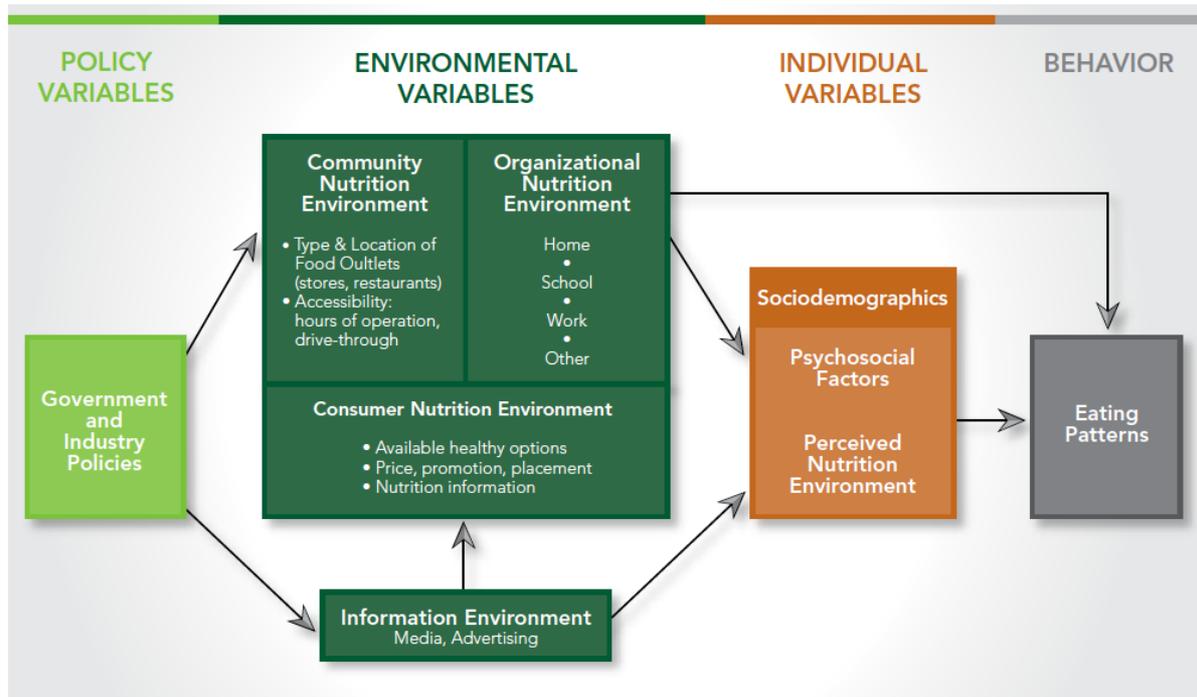


Figure 1. Model of the Community Nutrition Environment
 Source: Health Canada. (2013). Measuring the Food Environment in Canada. Ottawa: Minister of Health; Canada. Available at: www.hc-sc.gc.ca/fn-an/nutrition/pol/index-eng.php

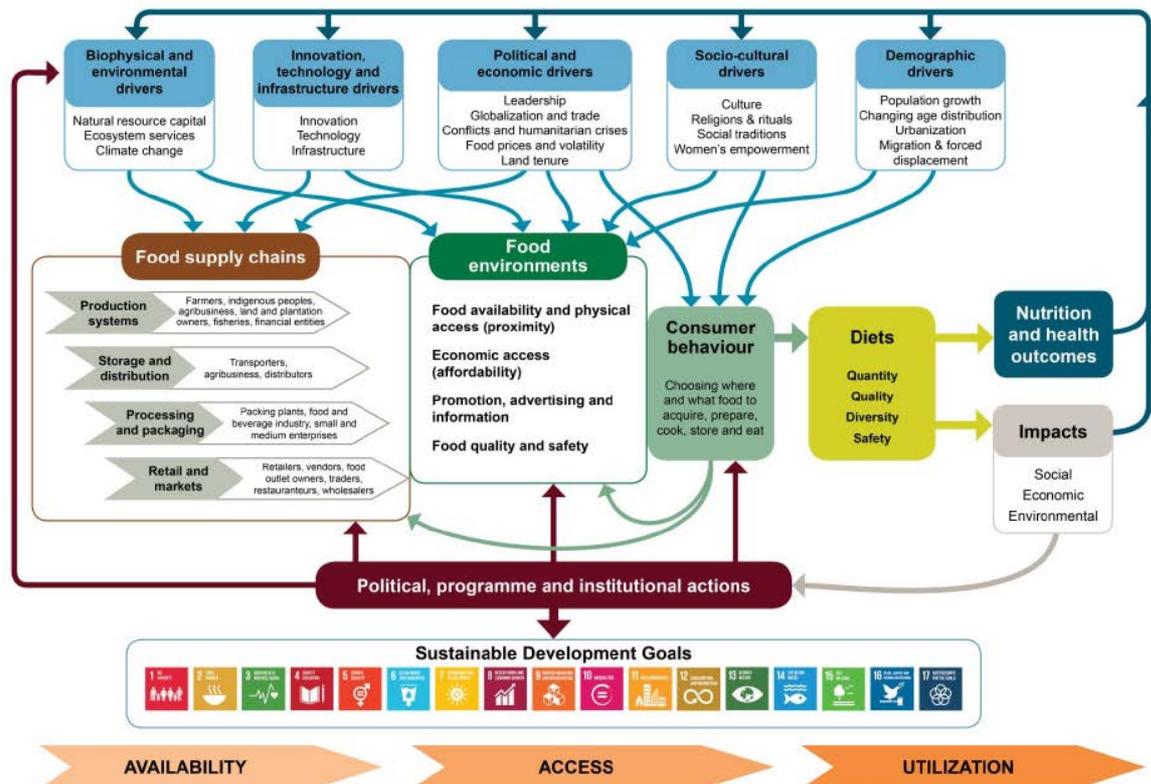


Figure 2. Conceptual Framework for Food Systems for Diets and Nutrition
 Source: HLPE. (2017). Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: FAO. Available from: <http://www.fao.org/cfs/cfs-hlpe/en/>

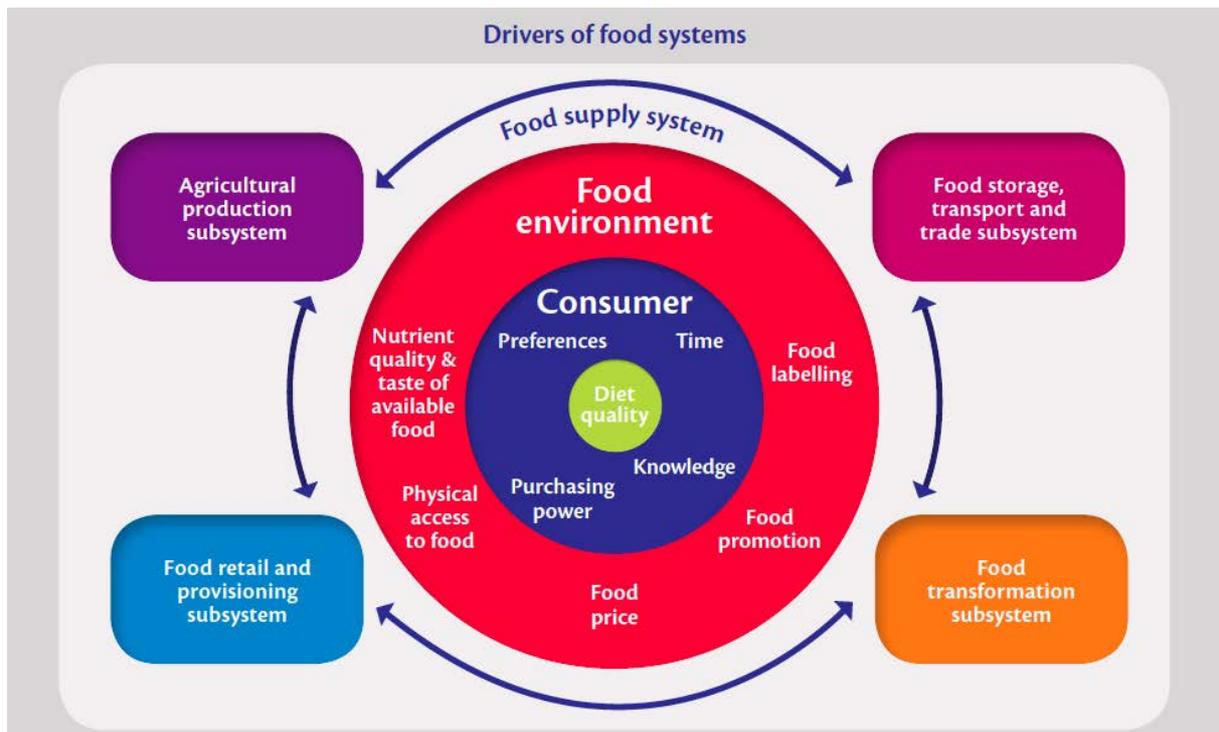


Figure 3. Conceptual Framework for the Links Between Diet Quality and Food Systems
 Source: Global Panel on Agriculture and Food Systems for Nutrition. (2016). Food systems and diets: Facing the challenges of the 21st century. London, UK: GLOPAN. Available from: <https://www.glopan.org/foresight>

Appendix 2

Table 1: Primary and secondary outcomes

Outcomes	Measures
Primary Outcomes	
Anthropometric outcomes	Incidence, prevalence or mean difference in: <ul style="list-style-type: none">• Stunting• Wasting• BMI, age- and sex- standardized body mass index (zBMI or BMI z-scores), overweight, obesity• Lean mass %, fat mass %• Waist circumference, waist-to-hip ratio
Diet-related health outcomes (other than body weight)	Incidence, prevalence or mean difference in: <ul style="list-style-type: none">• Anemia• Type 2 diabetes• Mean systolic blood pressure• Lipid profiles• Hb concentration• Serum ferritin, serum retinol, serum folate, blood glucose, urinary nitrogen
Secondary Outcomes	
Direct measures of consumption	Frequency of consumption, energy intake, food group intake, food consumption score, dietary diversity score, mean difference in portion size
Place of consumption	Change in place of consumption (i.e that reduces or increases risk of a diet-related health outcome – home to consumer/restaurant location, restaurant to home, school to consumer)
Meal patterns	Breakfast skipping, snacking in place of meals, snacking in addition to meals

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