



Investing in rural people

Addressing overweight and obesity in LMICs in the realm of rural development and food systems

Global evidence base versus practice in five country examples

by

Marion Herens
Hermine ten Hove
Sanne Bakker
Joyce Njoro
Ilaria Bianchi
Sinafikeh Gemessa
Vibhuti Mendiratta

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<https://scholar.google.it/citations?user=ZUqz-8MAAAAJ&hl=en&oi=ao>

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Abstract

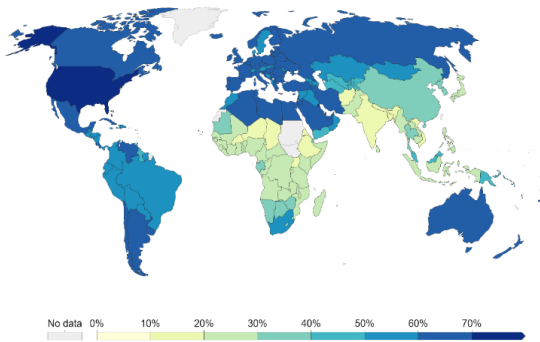
Overweight and obesity rates across low- and middle-income countries have approached levels found in high-income countries. While overweight and obesity are more prevalent in urban areas, they are also on the rise in rural areas. Little research has been conducted on the effects of food systems on overweight and obesity. This paper presents the findings of a comprehensive literature review of the evidence on the main drivers of overweight and obesity, described using a food systems framework and illustrated with concrete examples from five countries. Available evidence on intervention strategies with the potential to prevent and/or reduce overweight and obesity was also reviewed and compared with identified drivers and practice-based examples from the selected countries. This paper shows how systemic the issue of overweight and obesity is, with drivers being present in nearly each segment of the food system. It helps to explain the complexities of addressing overweight and obesity across different levels, and why there are few proven interventions that are effective at the individual level. The study results show that food system-related interventions are applying traditional approaches such as food package labelling, price manipulation and changing the food environment, and that there is a gap in evidence on what works and what does not. The findings in this paper could be used to inform future agriculture and food systems investments for better nutrition and health outcomes.

1. Introduction

Globally, overweight and obesity cost an estimated US\$2 trillion per year or 2.8 per cent of global gross domestic product (GDP) (Dobbs et al. 2014). The World Health Organization (WHO) identifies unhealthy diets as one of the risk factors that can cause overweight and obesity, which in turn increases the risk of non-communicable diseases (NCDs). Indeed, 74 per cent of all deaths in 2019 were caused by NCDs (World Bank 2020). Three of the four most common NCDs are diet-related, namely cardiovascular diseases, certain forms of cancers and diabetes (Development Initiatives 2020). It is estimated that 77 per cent of deaths from NCDs occur in low- and middle-income countries (LMICs) (WHO 2021a). Overweight and obesity have now emerged as a global challenge, affecting high- and low-income countries alike (see figures 1, 2, 3 and 4).¹

Figure 1. Share of adults who are overweight or obese, 2016 **Figure 2.** Share of children who are overweight or obese, 2016

Share of adults that are overweight or obese, 2016
Being overweight is defined as having a body-mass index (BMI) greater than or equal to 25. Obesity is defined by a BMI greater than or equal to 30. BMI is a person's weight in kilograms divided by their height in meters squared.

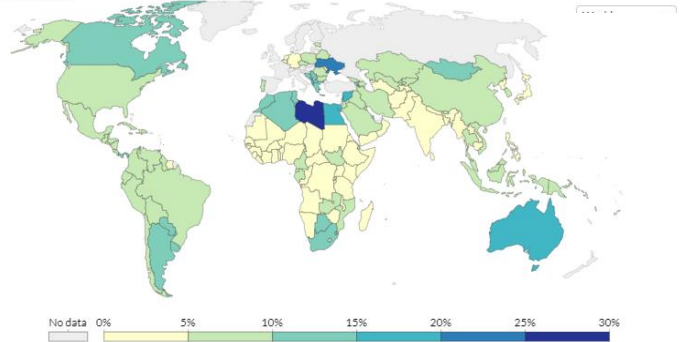


Source: WHO, Global Health Observatory

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Share of children that are overweight or obese, 2016

Share of children under five years old that are defined as overweight or obese. A child is classified as overweight if their weight-for-height is more than two standard deviations from the median of the World Health Organization (WHO) Child Growth Standards.

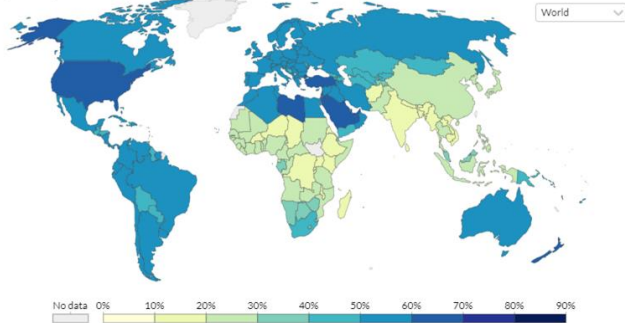


Source: WHO, Global Health Observatory (GHO)

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Figure 3. Share of adults who are overweight or obese, 2006 **Figure 4.** Share of children who are overweight or obese, 2006

Share of adults that are overweight or obese, 2006
A person is defined as overweight if they have a body-mass index (BMI) equal to or greater than 25. BMI is a person's weight in kilograms divided by his height in metres squared.

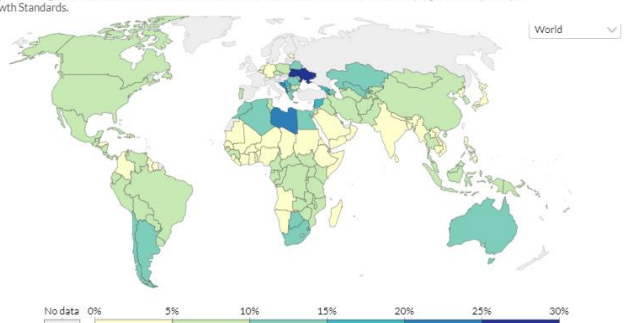


Source: WHO, Global Health Observatory

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Share of children that are overweight or obese, 2006

Share of children under five years old that are defined as overweight or obese. A child is classified as overweight if their weight-for-height is more than two standard deviations from the median of the World Health Organization (WHO) Child Growth Standards.



Source: WHO, Global Health Observatory (GHO)

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Source: Ritchie and Roser (2017). Data source: WHO (2017).

Comparing 2006 and 2016 (figures 1 and 3), it can be concluded that the number of countries with over a 60 per cent share of adults who are overweight or obese has greatly increased in those 10 years, especially in Europe and North Africa. Asia and Africa are the only continents home to countries with less than a 30 per cent share of adults who are overweight or obese. LMICs with over a 50 per cent share of adults who are overweight or obese are mainly found in South and Central America, North Africa and the Middle East.

¹ Figures 1-4, dating from 2016, present the most recent global overweight and obesity data. At the country level, more recent data are available for some countries, which suggests that the current global picture is even worse.

Childhood overweight and obesity rates also increased between 2006 and 2016, albeit more slowly (figures 2 and 4). The exceptions are Central and Southern Africa, where the number of countries with over a 5 per cent share of children who are overweight or obese seems to have reduced. These figures are for children under 5 years of age; they are expected to be higher for older children.

These trends towards overnutrition, however, do not negate the need to address problems of undernutrition. Undernutrition and/or micronutrient deficiencies can occur alongside overweight/obesity or diet-related NCDs (the so-called double or triple burden of malnutrition) co-existing at the individual, household, community and population level and/or across the life course (WHO n.d.).

The root causes of overweight and obesity are highly complex, with myriad factors at multiple levels that directly or indirectly affect nutrition outcomes. While there are many determinants of overweight and obesity – for instance, in the realms of psychology, the media, activity, infrastructure, social and individual psychology, and physiology – the changes in the food system seem to be the major drivers for the rise in overweight and obesity (Swinburn et al. 2011). Yet overweight and obesity are generally viewed from a public health rather than a food systems perspective. An increasing amount of research is focusing on food environment/food system factors such as the production, marketing, affordability and accessibility of foods that affect dietary choices, to more systematically prevent and control diet-related diseases and overweight and obesity (Crino et al. 2015; Driessen et al. 2014; Hall 2018; Herforth and Ahmed 2015; Williams et al. 2014). Little research, however, has been conducted on the role of food systems in addressing overweight and obesity and the control of diet-related diseases in rural areas. The overall objective of this study is to deepen the knowledge on how agriculture and food value chains can contribute to mitigating the rising incidence of overweight and obesity in LMICs from a food systems perspective.

In this paper, we aim to answer the following research questions:

- What are the drivers and causes of overweight and obesity in the food systems in the context of rural areas in LMICs?
- What evidence is available on intervention strategies with the potential to prevent and/or reduce overweight and obesity in the different areas of the food system?

After explaining the methodology (chapter 2), this paper provides an update of the evidence on drivers and intervention strategies for overweight and obesity, alongside practice-based examples of LMICs (chapter 3), which could be used to inform future agriculture and food systems investments for better nutrition and health outcomes.

2. Methods

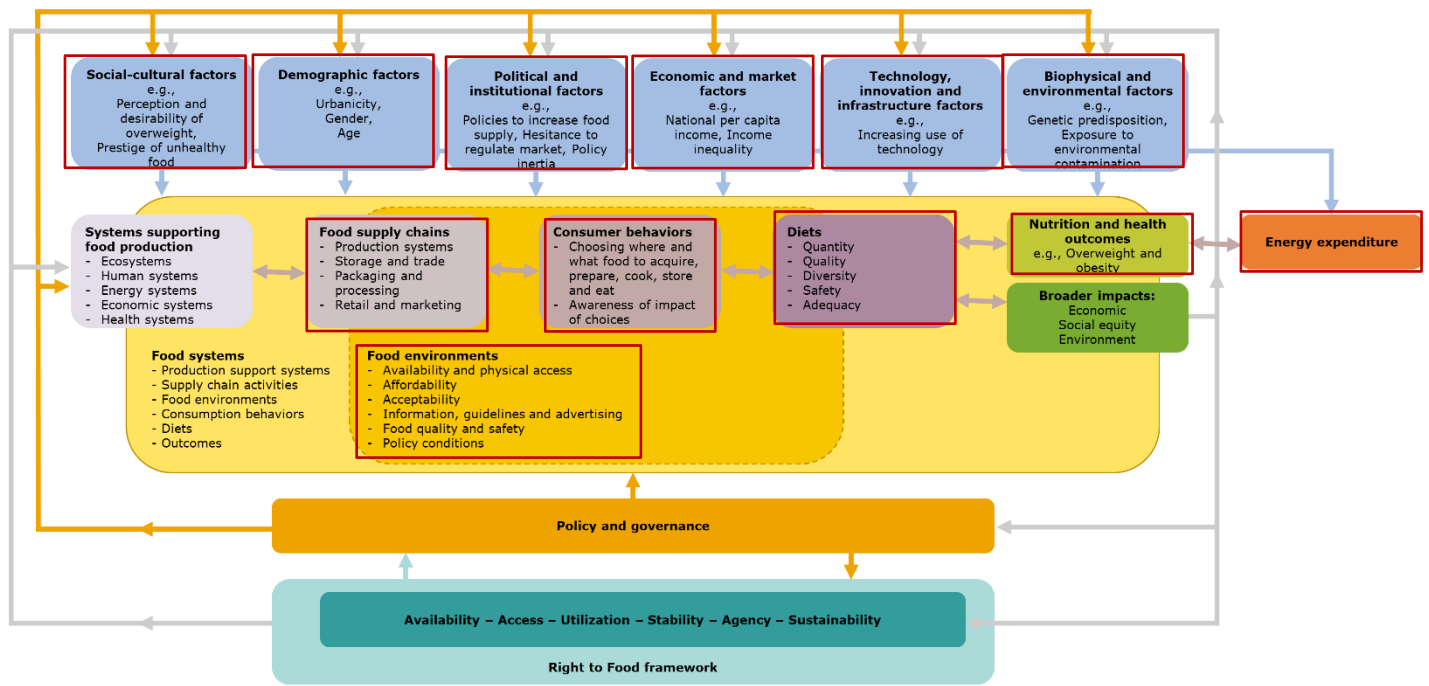
2.1. Theoretical grounding

At the core of the food systems approach lies the food supply/value chain dimension, as they play the central role in delivering nutritious foods to consumers at affordable prices (Allen and de Brauw 2018), while also influencing the demand for nutritious foods. Value chain interventions have been recognized for their considerable potential to help reduce all forms of malnutrition, including overweight and obesity. Moreover, food value chains have also been identified as one of the three fundamental elements of food systems – in addition to consumer behaviour and the food environment – to potentially determine an individual's diet (de Brauw et al. 2019; HLPE 2015). The food environment is shaped by multiple value chains consisting of the actors necessary for the production, distribution and retailing of multiple products (de Brauw et al. 2019).

This comprehensive review is anchored in the High Level Panel of Experts (HLPE) 2017 and 2020 reports. The drivers of obesity and overweight, as well as preferred or recurrent intervention strategies are mapped using various dimensions of the HLPE Sustainable Food Systems

Framework (see figure 5). As the original HLPE framework only focuses on the consumption side of the energy equation, it was expanded with an “energy expenditure” box to ensure that both fundamental drivers of overweight and obesity are covered. The framework was also adapted to replace the term “drivers” with “factors”, to prevent confusion between the HLPE’s definition of “drivers” and the different definition of the term that this paper maintains (see box 1).

Figure 5. Sustainable Food Systems Framework adapted for specific drivers and intervention strategies for overweight and obesity identified in the literature review.



Source: Adapted from HLPE (2020).

2.2. Comprehensive literature review

The approach of the comprehensive literature review of the evidence on the main drivers of overweight and obesity in rural areas of LMICS builds on a mix of review methodologies and underlying protocols. The methodology was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA): an evidence-based guideline to transparently report on reviews (Page et al. 2021). We split the literature review into two main components: (i) drivers of overweight and obesity in rural areas in LMICs; and (ii) intervention strategies for overweight and obesity. A combination of the key words was applied, and Scopus was used as a search engine to gain access to the full documents behind the search results. A snowball approach was used – i.e. the references cited in relevant materials were used to obtain further sources.

The inclusion criteria used in this comprehensive review were: peer-reviewed journal articles; covering rural populations; and covering LMICs. The exclusion criteria were as follows: overweight or obesity is not mentioned in the abstract text; based on anecdotal or perception-based evidence; article focuses only on causes of overweight and obesity on a molecular, cellular or physiological level; and article only considers overweight and obesity as a driver of other topics such as public health costs, disorders, diabetes or cancer.

The studies that identified drivers and causes (see box 1) were assessed to determine the type of conclusions that can be drawn from them based on study type, use of counterfactual, and considering limitations to the internal and external validity of the findings. The identified drivers and causes were subsequently grouped according to the components of the HLPE Sustainable Food Systems Framework. Analysis was carried out using NVivo 12 qualitative analysis software.

Relevant excerpts from the articles were coded according to a predefined coding list (based on the review questions).

Box 1. Clearing up the terminology of causality

The terms “cause” and “driver” are used in the research questions. The latter tends to be defined differently by different authors. In this box, we clarify our usage of the two terms. The term **cause** is only used when there is sufficient evidence to establish at least **the causal effect** or **causal mechanism** of a given phenomenon, or both. For other factors for which “some evidence of causal association with the outcome of interest is presented, but for which the evidence or knowledge is not sufficient to firmly establish the causal effects and explain the causal mechanisms of a specific phenomenon”, the term **driver** is used instead, following the definition suggested by Meyfroidt (2016).

To understand the intervention strategies for overweight and obesity, a similar analytical process as described above was employed. Non-scientific publications from the search engines of the prestigious organizations in the food domain (e.g. Agris (FAO) and OAister) were also included. The following inclusion criteria were used: covers rural populations; covers LMICs; and describes how the intervention strategy contributes to controlling and/or reducing overweight and obesity. The following exclusion criteria were used: information is over 10 years old (will be applied as a search filter); and covers only high-income segments of low-income countries (LICs). These categorizations were also guided by the HLPE Sustainable Food Systems Framework. Only the papers with quantitative evidence or a strong claim of the causal relationship between the interventions and mitigation of overweight and obesity were reported.

2.3. Country mapping

To build more contextual understanding of overweight and obesity in LMICs, a country mapping was conducted. Five countries were selected based on prevalence of overweight and obesity; country income classification; size of population; upcoming IFAD project designs or Country Strategic Opportunities Programmes (COSOPs); explicit in-country (policy) interest in overweight and obesity; and representation of different IFAD regional contexts. The selection included Indonesia, representing the Asia and the Pacific Region (APR); Zambia, representing East and Southern Africa (ESA); Egypt, representing the Near East, North Africa, Europe and Central Asia (NEN); Nigeria, representing West and Central Africa (WCA); and Bolivia, representing Latin America and the Caribbean (LAC).

With the support of IFAD headquarters and country teams, relevant documents and information sources were collected to explore ongoing activities and intervention strategies in the domain of overweight and obesity in each country. Data sources analysed included programme documents for each IFAD country portfolio of loans and grants (including COSOPs, project design reports, supervision mission reports, national and sub-national policy and strategy documents and corresponding action plans, national surveys reporting on food systems outcomes (mainly social, economic, nutrition and health), country-specific peer-reviewed scientific articles on overweight and obesity, and any additional documents resulting from applying the snowballing techniques.

All documents retrieved were analysed using NVivo 12 qualitative analysis software. Relevant excerpts from the articles were coded according to a predefined coding list based on the review questions. The country mapping was complemented by an online stakeholder consultation in each country, except Indonesia,² to present the preliminary findings to key informants working on the nexus between agriculture, food systems and health promotion. Stakeholders were representatives of the government, United Nations agencies, the donor community, research institutions, academia, civil society and the private sector. Online dialogues were captured using Google Jam for feedback to participants and further analysis, as well as recordings of the sessions

² The workshop in Indonesia did not take place because it could not be organized within the defined time frame of the country mapping.

(Zoom software). These outputs were analysed using the same coding as was used for the desk review.

Limitations

Data on overweight and obesity prevalence that allow for global comparison are very scarce. This limits the analysis of potential drivers and solutions to the growing obesity problem in different countries. Consistent data on overweight and obesity across different age groups representing rural and urban areas were not found.

3. Findings

3.1. Drivers and causes of overweight and obesity from a food system perspective

This section describes the drivers and causes identified in the comprehensive literature review, and related examples from the country mapping. The **causes and drivers of overweight and obesity** are organized and described according to the adapted HLPE 2020 framework (HLPE 2020) shown earlier in figure 5: diets and energy expenditure; consumer behaviour; food environment; food supply chains; sociocultural factors;³ demographic factors; political and institutional factors; economic and market factors; technology, innovation and infrastructure factors; and biophysical and environmental factors.

Energy expenditure

A positive energy balance drives weight gain, which means that energy expenditure is insufficient to balance energy intake. In LICs, 12 per cent of men and 24 per cent of women are insufficiently physically active to meet WHO guidelines – compared to 26 per cent of men and 35 per cent of women in high-income countries (HICs) (WHO 2020). While physical activity is beneficial in its own right, its role in the rising prevalence of overweight and obesity is likely limited compared to the role of high-energy diets leading to a positive energy balance (Swinburn et al. 2011).

Box 2. Lack of physical activity as a driver in Indonesia

Over the past 20 years, obesity has increased remarkably in Indonesia across all population groups, including rural and low-income strata. Panel regressions performed by Roemling and Qaim (2012) confirmed that changing food consumption patterns, coupled with decreasing physical activity, directly contributed to this trend. They found that individuals with sedentary jobs and those in housekeeping were more likely to be obese or pre-obese, whereas those who have higher levels of physical activity in their work are more likely to be of normal weight or underweight. Lighter levels of physical activity during work contributed to higher body mass index (BMI). For instance, working in a sedentary job, as compared to a job involving heavy physical work, increased BMI levels by approximately 0.6 for both men and women. They concluded that sedentary jobs and lower physical activity during leisure time may partly explain the higher prevalence of overweight and obesity in urban areas, but they are not restricted to urban areas only.

Diets

A **diet that is too high in energy** (relative to energy expenditure) is the main cause of weight gain (WHO 2021b). Since the early 2000s, dietary patterns globally have continued to change in response to consumer demands and market developments, triggered by rapid urbanization and the improving socio-economic status (SES) of the middle class (Popkin 2004; Popkin and Gordon-

³ Note that a “food system driver” is not the same concept as a “driver to overweight and obesity” (see box 1 for a definition of the latter).

Larsen 2004). In a study on ultra-processed foods,⁴ Baker et al. (2020) flagged the concern of the rising supply of **caloric sweeteners** (e.g. added sugars), in particular when consumed in beverages (soft drinks, juices or alcoholic drinks, or added to tea or coffee), as liquid calories are less satiating than solid foods so are likely to be consumed in excess. Sugar-sweetened beverage consumption is on the rise in LMICs (Ford et al. 2017; Malik and Hu 2022). Evidence indicates that increases in BMI reduce over time when the consumption of sugar-sweetened beverages is reduced, indirectly showing that the consumption of sugar-sweetened beverages can cause weight gain (Malik and Hu 2022). Global availability and affordability of **edible plant oils** has risen sharply. Its use in processed foods has contributed to changing food consumption behaviours, such as snacking and the consumption of (ultra-)processed foods and fast foods (Drewnowski and Popkin 1997; Ford et al. 2017). The availability of alcohol is also on the rise in LMICs, with WHO reporting a general trend towards a greater availability of alcohol around the clock, as well as a shift towards commercialized European-style alcoholic beverages rather than those produced by local communities and indigenous groups (WHO 2019).

Box 3. Unhealthy diets in Nigeria

A meta-analysis carried out to inform the formulation of a Multi-Sectoral Action Plan for the Prevention and Control of NCDs broadly defines unhealthy diets as “having less than 3-5 servings of fruits and vegetables per day, and/or daily intake of high fat or high sugar meals”. In that meta-analysis, the prevalence of consuming an unhealthy diet was shown to be 74.8 per cent in Nigeria, and similar for both men and women (Federal Republic of Nigeria 2019).

Nutrition and health outcomes

There are several ways in which the nutrition and health outcomes of the food system can contribute to the prevalence of overweight and obesity.

Maternal BMI and diet can predict or influence a child’s likelihood of becoming overweight or obese over the course of their life in multiple ways. One way is the mother **being** obese herself. This is associated with a higher likelihood of her child becoming obese in MICs and HICs. More research is needed to establish the causality of this association (Castillo-Laura et al. 2015; Ford et al. 2017). Another way is by an insufficient intake of energy, protein and micronutrients by the mother during the first half of her pregnancy. This is shown to be related to increased adiposity in her female offspring (Jaacks et al. 2017; Yang and Huffman 2013). The opposite effect is observed when women face famine in the last trimester of their pregnancy and after birth: their offspring have a lower risk of obesity (Yang and Huffman 2013).

Being breastfed exclusively is associated with a slower rate of weight gain, and possibly a decreased risk of being overweight in childhood and adolescence. However, the studies that demonstrate this effect were based in HICs and often had a control group that was formula-fed. The higher protein content of formula could therefore be a factor in this effect, as excessive protein intake and rapid weight gain in infants are associated with increased risk of obesity later in life (Yang and Huffman 2013).

Lastly, some studies suggest that the gut microbiome can act as a driver. Evidence from animal studies suggests that a change from a traditional diet towards a Western diet causes changes in the composition of the microbiome, increasing the uptake of calories from the diet and altering energy metabolism (Ford et al. 2017; Turnbaugh et al. 2008).

⁴ Ultra-processed foods are produced using many types of additives. The processes and the ingredients used in the manufacture of ultra-processed foods make them convenient (ready to consume, almost imperishable) and attractive (hyperpalatable) for consumers, and profitable (low-cost ingredients, long shelf life) for their manufacturers. However, these processes and ingredients also make ultra-processed foods typically nutritionally unbalanced and liable to be over-consumed (Monteiro et al. 2019).

Consumer behaviour

A systematic review by Karanja and colleagues (2022) studied the **individual-based motives** for food choice in LMICs, and “weight consciousness in pursuit of an ideal body size” was identified in four studies (in Brazil, China, Iran and Malaysia). Karanja et al. (2022) concluded that the body of evidence on individual-based motives for food choice is fragmented, and that there is a dearth of studies in rural areas (15 per cent of the studies they found) – focused mostly on food taboos with no apparent relation to overweight and obesity (e.g. prohibition of certain foods or food types during pregnancy, lactation or menstruation).

Box 4. Awareness of impact of choices

While the literature review did not retrieve information on the role of awareness of weight gain and adverse health effects as a potential consequence of consumer choice as a potential driver or cause of overweight and obesity, a lack of awareness among consumers was flagged by stakeholders across all the focus countries, and they are taking action – mainly through media campaigns.

For example, in Bolivia, media campaigns are in place advocating the reduction of consumption of ultra-processed foods. Under the slogan “Eat rich, Eat natural, Eat without chemicals”, the consumption of more traditional and organic food is promoted. In Egypt, nationwide programmes are being implemented to raise public awareness and/or track and monitor the state of general health and promote physical fitness and well-being. In Nigeria, vegetable consumption is promoted, while in Zambia, as part of its social protection scheme, messages are provided under a “Healthy diets” campaign on how to use money to acquire food, not only for children but also adults. In Indonesia, the Healthy Community Movement, known as GERMAS, has been in place since 2017, geared towards accelerating and harmonizing the promotive and preventive efforts related to healthy living, to increase the population’s productivity and reduce the disease-related burden of health care costs.

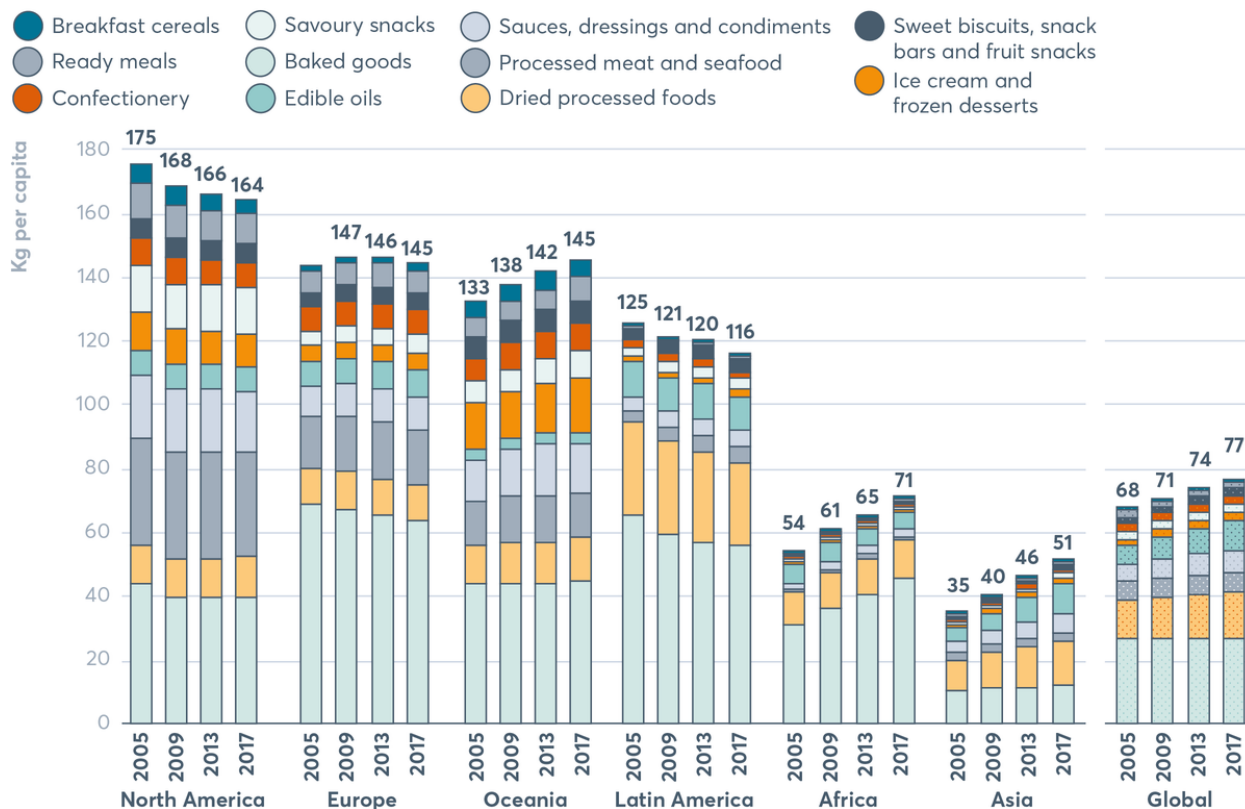
Food environment

The food environment includes food availability and physical access (proximity); economic access (affordability); promotion, advertising and information; convenience and time savings; and food quality and safety (Herforth and Ahmed 2015).

Two types of food environments were found that may be conducive to the prevalence of overweight and obesity: **food deserts and food swamps**. Food deserts are characterized by a relative lack of nutritious food options and are widespread in middle-income countries (MICS) such as Brazil and relatively rare in LICs due to the presence of informal markets. Food swamps, meanwhile, are inundated by the availability of unhealthy food, and were identified in Mexico (Swinburn et al. 2019; Turner et al. 2020). Swinburn et al. (2011) found that the increased availability of cheap, tasty and highly promoted obesogenic foods acts as the main driver of the global obesity epidemic – though they note that this hypothesis is mainly based on data from the United States of America and would need to be validated in other countries.

Food availability – and especially the availability of packaged food – is found to be of particular relevance. Manufacturing and consumption of ultra-processed foods are on the rise (Global Food Research Program 2021). Globally, total sales volumes of packaged food rose from 67.7 kg per capita in 2005 to 76.9 kg per capita in 2017. Figure 6 reveals the trends and patterns in per capita sales of different categories of packaged food by region, between 2005 and 2017, showing that Europe and North America purchase the highest volumes of packaged foods, yet sales growth is stagnant or going down. Africa and Asia, the regions with the largest populations, show a significant increase in the volume of sales of packaged food, though starting from a lower baseline. These packaged foods are usually processed, which in most cases increases the content of added or free sugars, saturated and trans fat, salt and dietary energy density, while decreasing protein, dietary fibre and micronutrients (Development Initiatives 2017). Such foods tend to be **convenient** and may have a longer shelf life.

Figure 6. Trends and patterns in per capita sales of different categories of packaged foods by region, 2005-2017



Source: Development Initiatives (2018).

Food affordability – specifically, the affordability of high-calorie foods – is found to be a driver of overweight. Evidence from various studies suggests that the relative cheapness of unhealthy calories is an important explanation for the obesity epidemic. Most of this evidence comes from HICs, but, as shown in table 1, unhealthy foods are also relatively inexpensive in LICs. As a result, 3 billion people cannot afford a healthy diet (Herforth et al. 2020). It demonstrates that healthy foods are relatively more expensive in poorer countries than in richer ones (Headey 2019).

Table 1. Relative caloric prices across food groups and national income levels

	All countries (N=176)	High income (N=64)	Upper middle (N=44)	Lower middle (N=41)	Low income (N=27)
Fats and oils	0.67	0.66	0.49	0.75	1.05
Sugar	0.83	0.36	0.57	1.06	2.07
Soft drinks	5.26	3.30	3.55	6.72	11.45
Juice	12.62	3.16	11.59	18.23	11.78
Sugary snacks	2.16	1.43	2.09	2.44	2.92
Salty snacks	2.54	1.81	2.24	2.54	6.88
Milk	3.84	1.93	2.72	4.55	10.45
Other dairy	6.93	2.46	6.25	9.40	8.53
Eggs	5.54	2.60	4.46	6.65	11.66
White meat	5.42	3.91	3.54	6.98	9.97
Red meat, unprocessed	3.07	3.07	2.68	3.30	3.72
Red meat, processed	11.51	7.50	9.34	14.89	15.26
Fish and seafood	6.00	5.65	4.31	6.90	10.20

Source: Adapted from Headey and Alderman (2019).

Note: Relative caloric prices (RCPs) are defined as “The ratio of the price of 1 calorie of a given food to the price of 1 calorie of a representative basket of starchy staple food in each country. These RCPs have a simple interpretation: an RCP of 5 for eggs implies that it is 5 times as expensive to obtain a calorie from eggs as it is to obtain a calorie from starchy staples” (Headey, 2019). The prices are not linked to a currency.

Table legend:	Relative caloric price of <2.00	Relative caloric price of <4.00	Relative caloric price of <8.00	Relative caloric price of >8.00
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Experimental studies in HICs show that food advertising for (unhealthy) food and drinks targeting children can cause an increase in energy intake (Goris et al. 2010; Sadeghirad et al. 2016), which could contribute to overweight prevalence.

Food supply chains

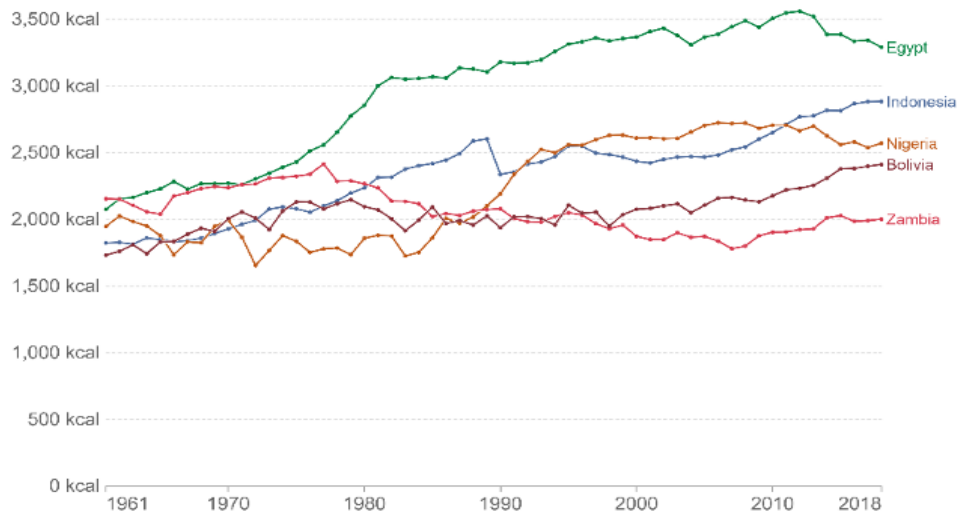
Globalization of food supply chains, facilitated by trade liberalization, has influenced food systems in LMICs (Kennedy, Nantel, and Shetty 2004). It has led to more food imports,⁵ more direct investment in food production and processing, and the growth of transnational food companies. This, in turn, has effects on food availability and pricing – also of processed and fast foods. Ultimately, it has contributed to increased consumption of snacks and fast food (Ford et al. 2017). At national level, **the Green Revolution** (in the 1960s and 1970s) has increased the production of staple foods in developing countries (e.g. rice, wheat and maize) to date, and led to a shift in prices that made staples more affordable relative to other food groups, such as legumes, vegetables and fruits (World Bank 2017). Food supply chains providing high-energy foods can be expected to contribute to **increases in food energy supply** (expressed in kJ/day of supply per citizen) sufficiently to explain increases in average population body weight, especially in HICs (Vandevijvere et al. 2015). The role of an increased food energy supply in LMICs is less described in literature, which could be explained by poorer data availability and higher reliance on subsistence farming (which is not tracked by Food and Agriculture Organization of the United Nations [FAO] food supply data). Songsermsawas et al. (2022) showed that food value chain development projects supported in part by IFAD in the Solomon Islands and Papua New Guinea contributed to improved dietary diversity but also to a higher likelihood of consuming sweets in both countries, and more oils in Papua New Guinea.

Box 5. Food energy supply and overweight and obesity trends in selected countries

Looking at the development of the daily supply of calories per person over the past five decades (see figure 7), in Egypt and Indonesia the daily supply of calories has increased considerably since 1961, and in Nigeria since the 1990s. Since 2010, the trend seems to have stabilized in all five countries (until 2016). It is also noteworthy that Zambia had the highest daily supply of calories per person in 1961 and the lowest in 2018. It is the only one of the five countries where the daily supply of calories per person did not increase between 1961 and 2018.

⁵ The top five crops most imported into least developed countries in 2019 were wheat, rice, sugar, palm oil and maize (FAO 2019).

Figure 7. Daily supply of calories per person, 1961-2018

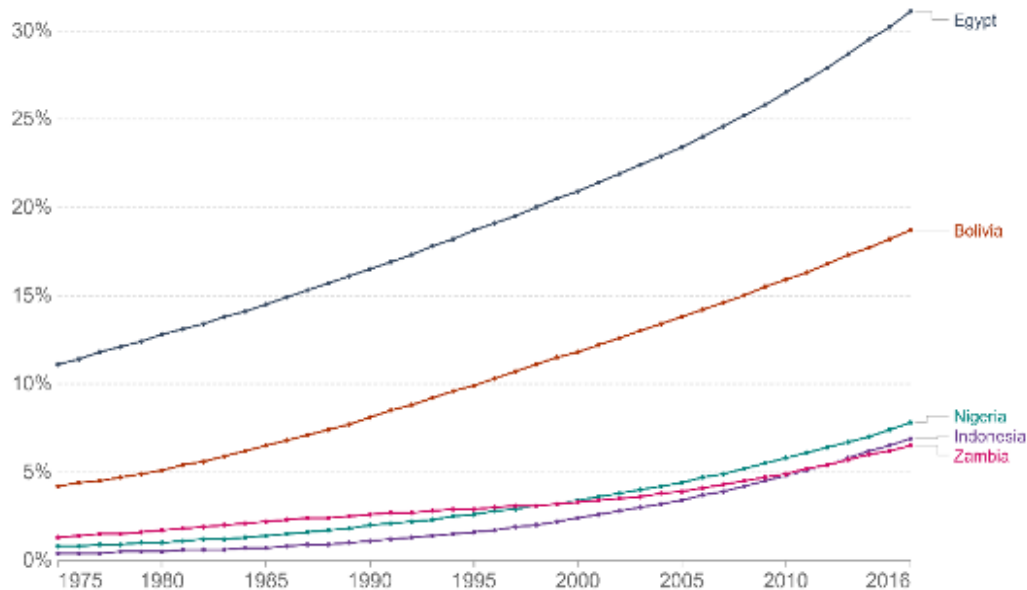


Source: Roser, Ritchie, and Rosado (2018). Data source: FAO (2023).

Note: Daily per capita caloric supply measured in kilocalories per person per day.

Looking at the trend in the development of obesity, however, an ongoing gradual increase in obesity in all countries can be observed (figure 8). Egypt has the highest levels of obesity of the five countries, but the rate of increase is about the same in all countries. This suggests other factors at play than just the daily supply of calories in whatever form.

Figure 8. Share of adults who are obese (BMI ≥ 30), 1975–2016



Source: Ritchie and Roser (2017). Data source: WHO (2017).

Sociocultural factors

Culture plays a role in people's perception of overweight. Studies show that incorrectly **perceiving one's weight as being overweight** in some cultures possibly has a negative effect on the effectiveness of overweight prevention programmes (Jaacks et al. 2017). **Desirability of being overweight** can be a factor too. For example, in some LMICs it is desirable for a child to be fat, as it is considered a sign of health and wealth (Fruhstorfer et al. 2016). Similarly, a large body size in adults is considered a positive attribute in some cultures (e.g. Tonga) (Kanter and Caballero 2012; Swinburn et al. 2011). Consumption of unhealthy foods may also carry a certain **prestige**. Culture also plays a role on the energy expenditure side of the equation in cultures where physical inactivity is associated with high social status (Kanter and Caballero 2012).

Box 6. Sociocultural drivers documented in selected countries

In all countries included in the country mapping, customs, habitual behaviours and practices, and misconceptions about body and health are flagged as important barriers – for example, overweight babies considered to be healthy babies and therefore fed junk food, or thinness associated with HIV/AIDS and poverty. Jaacks et al. (2017) report a case in Nigeria where consumption of processed foods was associated with higher social standing. Generally, a lack of healthy and active lifestyle “literacy” was flagged, indicating a lack of personal skills and motivation, requiring education and social behaviour change strategies.

In-country diversity in cultural beliefs and habits, flagged in particular in Bolivia and Indonesia, may hamper large-scale implementation of national food and nutrition security guidelines, so campaigns or social and behaviour change communication strategies and communication media need tailoring to the different geographical contexts.

Demographic factors

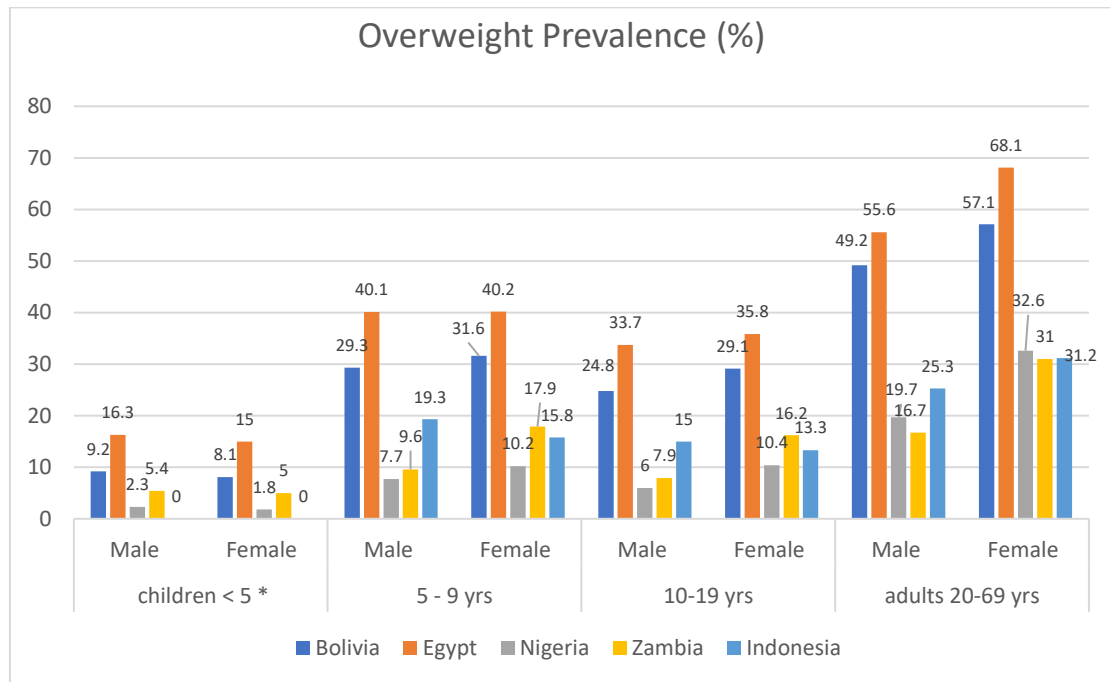
There is a clear positive association between **urbanicity** and obesity in LMICs. However, the difference between urban and rural populations is shrinking due to increases in overweight among rural populations. While overweight prevalence continues to increase in both rural and urban areas, the rate of increase is higher in many rural populations (Ford et al. 2017; Goryakin and Suhrcke 2014). A 2014 study in LMICs found that in about half of all countries surveyed (33 per cent) overweight in (adolescent) women has been increasing over the past decades at a rate greater in rural areas than in urban areas (Jaacks, Slining, and Popkin 2015a; 2015b). Urban environments differ from rural ones in terms of need for physical activity (different infrastructure, methods of transport, employment types, etc.), income levels, SES and food access (higher availability of calorie-dense cheap foods) (Ford et al. 2017). Evidence from China between 1991 and 2004 suggests that as a country develops economically, the aspects of urbanicity that lie at the root of overweight prevalence spread into rural areas, and the distinction between urban and rural areas in terms of overweight prevalence becomes less pronounced (Van de Poel, O'Donnell, and Van Doorslaer 2009).

Gender and **age** are two demographic drivers of overweight and obesity. Women are more likely to be overweight or obese than men in nearly all LMICs. Ford et al. (2017) list various possible explanations: differing physiological responses to early-life nutrition; differing hormonal responses to energy expenditure; weight gain associated with (a high number of) pregnancies; lower physical activity levels; depression; economic circumstances over the lifespan; and differences in sociocultural factors – such as ideal body size and acceptability of physical activity. Higher prevalence of overweight and obesity is found among older individuals than among younger groups (e.g. youth). It seems that the period of adolescence and youth roughly means the onset of higher obesity prevalence among females than among males. Before this period (i.e. during childhood), prevalence of overweight is similar between boys and girls (Ford et al. 2017).

Box 7. Demographics and overweight and obesity prevalence in selected countries

Figures 9 and 10 present the statistics on the prevalence of overweight in the five selected countries, drawn from global databases. Overweight and obesity increase with age, and differences between sexes are more prominent with increased age, in particular from 20 years onwards. Women are (much) more often overweight or obese than men. Another observation is that in the countries with high prevalence of overweight and obesity, it starts at an early age, in boys as well as girls. However, consistent data on overweight and obesity across different age groups representing rural and urban areas could not be found.

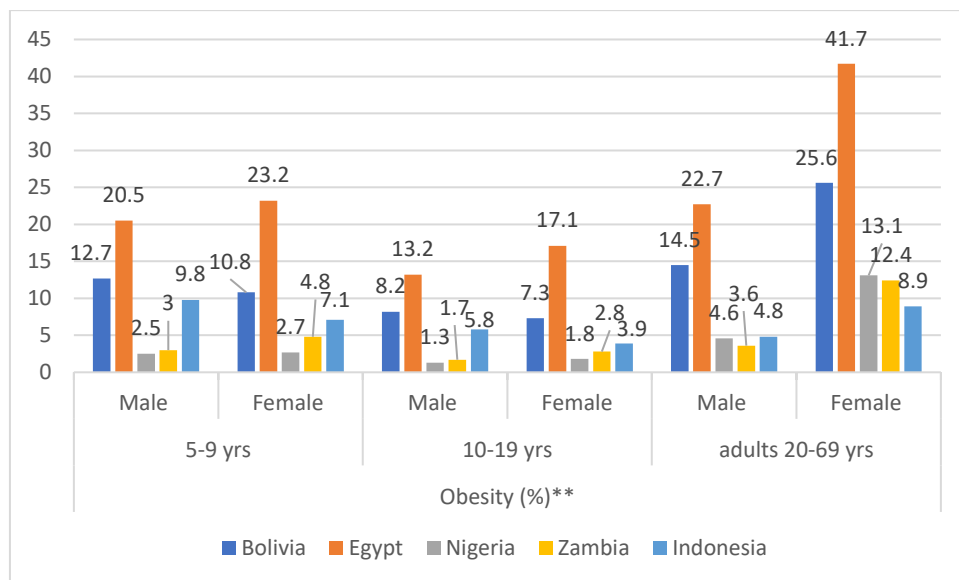
Figure 9. Prevalence of overweight in selected countries (%)



Source: Children <5: Bolivia: Demographic Health Survey (DHS) 2008 (Coa, Ramiro, and Ochoa 2009); Egypt: DHS 2014; Nigeria: DHS 2018; Zambia: DHS 2018; Indonesia: DHS 2017 (no data); children >5, adolescents and adults: WHO (2017).

Note: Children and adolescents: BMI >+1 standard deviation above the median (crude estimate) (%); adults: BMI >=25.

Figure 10. Prevalence of obesity (BMI >=30) in selected countries (%)



Source: WHO (2017).

Political and institutional factors

In the 1970s, the United States and other countries put **policies in place to increase food supply**. The resulting food supply is hypothesized to be so abundant that it has started to push up population energy intake (Swinburn et al. 2011). The extent to which this hypothesis about the role of policies to increase food supply could apply to LMICs is unknown. Nowadays, in countries where overweight and obesity are prevalent and where population energy intake is too high, a

hesitancy to regulate the market is observed. A food value chain that contributes to overweight and obesity is a natural consequence of a market-based economy that favours economic growth and liberalized, less regulated global markets. Regulatory approaches to address overweight and obesity are more difficult to achieve in an environment where policymakers are reluctant to intervene in a liberalized market (Swinburn et al. 2011). To explain the lack of uptake of existing evidence-based policy recommendations to halt the rising prevalence of overweight, Swinburn et al. (2019) coined the term “**policy inertia**”, meaning “a collective term for the combined effects of inadequate political leadership and governance to enact policies [...], strong opposition to those policies by powerful commercial interests, and a lack of demand for policy action by the public”.

Abay et al. (2020) highlighted significant relationships between trade (food) policy indicators and food availability indicators, and, ultimately, important relationships between trade policies and body weight outcomes. Alternative trade and food policies were assessed, including tariff rates on primary (food) products and food-specific tariff rates (e.g. cereals). They conclude that countries with lower tariff rates have higher overweight and obesity rates. In particular, countries that increase tariff rates on “unhealthy” foods (e.g. sugary foods and confectionery, fats and oils) are more likely to witness reductions in overweight and obesity rates (Abay et al. 2020).

Box 8. Food subsidy programme in Egypt

The Egyptian food subsidy programme provides staple foods at subsidized prices to a majority of the population. These subsidies are delivered through two separate programmes: the Baladi bread (and flour) programme and the ration card programme. The Baladi bread and flour subsidy programme aims to stabilize the availability and price of bread for the broader population. The ration card programme provides subsidies for other food items, including sugar and cooking oil. The food subsidy programme in Egypt costs the government about 2 per cent of GDP and represents 5–6 per cent of government expenditure annually (Abdalla and Al-Shawarby 2018, cited in Abay et al. 2020).

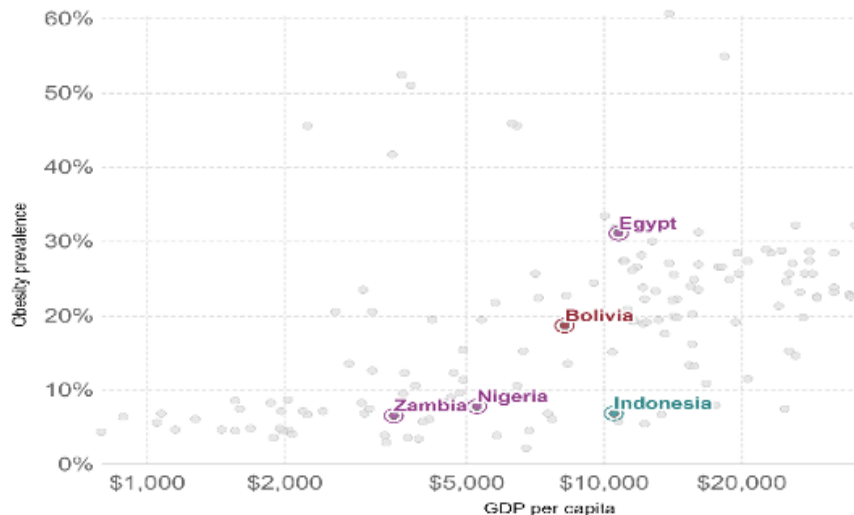
Economic and market factors

There appears to be a positive correlation between **national per capita income** and obesity prevalence. In other words, the prevalence of overweight or obesity in a country is likely to rise as that country develops economically (Fruhstorfer et al. 2016; Goryakin and Suhrcke 2014). Economic development also leads to decreasing levels of physical activity and increasing prevalence of sedentary lifestyles (WHO 2020). As nations become wealthier, there is a shift in which population segments are more susceptible to becoming overweight or obese. A study by Monteiro et al. (2004) found that in countries with GDP of less than US\$2,500, obesity prevalence is associated with a higher SES. To put it simply, in the poorest countries, it is the richer segments of the population that are more likely to be obese. This effect shifts at the US\$2,500 threshold: in relatively richer countries (upper-middle-income countries), it is the poor who are more likely to be obese. There is also a link between overweight/obesity prevalence and **income inequality**, though the exact effect is unclear. There is evidence that high income inequality is associated with higher prevalence of obesity – regardless of how wealthy a country is. Another study finds that – within the richest segment of LMICs – countries that have low income inequality see a faster increase in overweight in women among groups with lower SES than among groups with higher SES. The opposite applies to countries with high income inequality: here, the rise in overweight prevalence among groups with lower SES is slower than among groups with higher SES. These findings show that the effect of wealth on overweight prevalence is not universal, even at the same level of economic development (Ford et al. 2017; Jones-Smith et al. 2011).

Box 9. GDP and obesity prevalence in selected countries

Looking at the relationship between obesity and the countries' GDP, economic well-being seems to have a predictive power for obesity prevalence – more strongly so in Egypt and Bolivia than in Indonesia (see figure 11).

Figure 11. Share of adults who are obese vs. GDP per capita (2016)



Source: Our World In Data (n.d.). Data sources: WHO (2017) and World Bank (2022).

Note: BMI ≥ 30 ; GDP per capita measured in constant international \$.

Box 10. Household income and prevalence of overweight and obesity in Indonesia

People from higher income groups are more prone to being overweight and obese. According to Aizawa and Helble (2017), a 1 per cent increase in a household's wealth is associated with an increase of 0.6 percentage points in the probability of being overweight or obese. There is, however, evidence that the increase in the prevalence of overnutrition is increasing rapidly among poor households. Drawing on five rounds of Indonesian Life Family Surveys (1993, 1997, 2000, 2007 and 2014), Aizawa and Helble (2017) showed that while obesity among the richest quintile grew by 3.8 per cent per year between 1993 and 2014, it rose by 8.3 per cent per year among the poorest quintiles. No documents were identified showing more recent information about this trend.

Technology, innovation and infrastructure factors

The amount of energy needed to carry out various daily activities is becoming less and less, due to **increasing use of technology**. This applies to the shift from active transportation, where walking and cycling makes way for motorized transport. It also includes domestic work, where, for example, manual washing of clothes is replaced by the use of a washing machine. This trend can also be observed in occupational labour, as more and more people have sedentary jobs (Ford et al. 2017; Hallal et al. 2012; Popkin 2001). Farming is one of these occupations, as (sustainable) mechanization of farming is promoted with the objective of increasing land productivity, addressing labour shortages, decreasing its environmental footprint and reducing poverty (FAO n.d.).

Biophysical and environmental factors

One of the main biophysical drivers of overweight is **genetic predisposition**. The heritability of BMI is estimated to be between 40 per cent and 70 per cent (Allison et al. 1996; Herrera, Keildson, and Lindgren 2011). A person with a genetic predisposition does not necessarily develop overweight or obesity over the course of their life, as genes are not always expressed (Ford et al. 2017). Another, though very different, driver in the biophysical and environmental realm is **exposure to environmental contamination**. Persistent Organic Pollutants (POPs) are a group of chemicals that accumulate and spread in the environment and have significant negative effects on human health and the environment. Dichlorodiphenyltrichloroethane (DDT) is a famous example of this type of chemical. While many (high-income) countries prohibit the use of POPs, there are also numerous regions in LMICs where it is still applied – for malaria control, in the case

of DDT, but also as pesticides. Exposure to POPs seems to disrupt endocrine function⁶ and thereby increase obesity risk. However, the exact mechanism by which exposure to obesogenic POPs leads to increased obesity risk remains unknown (Ford et al. 2017; Grün and Blumberg 2006).

3.2. Interventions addressing overweight and obesity from a food system perspective

This section describes the findings from the comprehensive literature review and the country mapping on intervention strategies with the potential to prevent and/or reduce overweight and obesity. The overview is presented in table 2.

Food supply chains

Intervention strategies addressing overweight and obesity in the food supply chain contribute to creating conducive policy conditions and governance arrangements for a less obesogenic food system. Drivers of overweight and obesity in the food supply chain, identified in this study and described above, concern the globalization and modernization of food supply chains, including the use of additives, sugar and vegetable oils as part of food processing; political and institutional drivers focusing on increased food supply, food imports and food availability, and pricing, while being reluctant to regulate the markets; and environmental, dietary and food choice drivers.

Production systems

Very little evidence is found on production-related interventions. The literature review revealed studies focusing on the production of a specific food item as an intervention to reduce obesity, such as Siva et al. (2017), who claimed that lentils can be used as a food-based solution to combat global obesity. They argue that lentils contain rich, low-digestible carbohydrates stimulating the growth and activity of hind gut bacteria, which can lead to reduced obesity.

Findings from the country mapping reveal that the main intervention strategies identified in the production system tap into a wider pool of making diets healthier and more nutritious, and are defined as necessary strategies to set the scene for creating non-obesogenic food supply chains (Herens, ten Hove, and Perez Cardona 2023, forthcoming). They relate to strengthening nutrition-sensitive agriculture for improved dietary diversity and include promotion of production of vegetables and fruits, and neglected and underutilized species; homestead gardens; and bio-fortified food production and organic production, as a particular strategy to fill nutrient gaps.

While evidence from the literature points to single food-based interventions, the practice-based evidence points to dietary diversity-based interventions. Looking at the interventions and related drivers (see also table 2), we note that **diet quality** is a common driver across the evidence on intervention strategies. **Food availability, environmental contamination** and **pricing** are drivers associated with interventions identified in practice.

This might be explained by the fact that the intervention strategies highlighted in the country mapping originate from the latest established policies and action plans emphasizing dietary diversity as part of their overall food and nutrition security strategies. For example, the promotion of healthy and diverse diets is a main goal of the Political Constitution of the State (2009) in Bolivia,⁷ the National Food and Nutrition Policy and Strategy (2007-2017) of Egypt (WHO 2007) and the National Policy on Food and Nutrition (2017) of Nigeria (Federal Republic of Nigeria 2017). The underlying premise, consciously or unconsciously, is that diet quality affects overweight and obesity just as much as other forms of malnutrition. Another explanation might be

⁶ Endocrine function is the ability of the body to communicate internally through hormones.

⁷ Article 16 recognizes that the State must guarantee a healthy, adequate and sufficient diet for the population. See https://www.constituteproject.org/constitution/Bolivia_2009.pdf.

that the findings largely reflect a “business-as-usual” scenario when it comes to malnutrition, without a dedicated consideration of overweight and obesity at this level.

Transport, trade, processing and sales

The literature review revealed several intervention strategies on overweight and obesity in the transport, trade, processing and sales subsystem, relating primarily to policy and pricing interventions, food packaging, labelling and advertisements.

Taxation of unhealthy food products is a widely adopted food supply chain intervention. The intervention of high taxation of sugar-sweetened beverages has been subject to multiple studies because it can be an effective fiscal policy to reduce overweight/obesity prevalence because purchase and consumption of sugar-sweetened beverages decrease, especially when the tax is specific to beverage volume (Itria et al. 2021). Some studies show proof of effectiveness of this intervention (Cabrera Escobar et al. 2013; Lobstein, Neveux, and Landon 2020). Other studies did not find proof of effectiveness (Snowdon and Thow 2013; Pfinder et al. 2020). Nakhimovsky et al. (2016) found that while a tax on sugar-sweetened beverages may be a promising policy for MICs to prevent further increase in overweight (when it brings up the price by at least 20 per cent), the effect of the taxation alone will not be significant enough to ensure a permanent reduction in population weight.

Reduction of import duties on fruits and vegetables in Fiji contributed to increased volumes of fruits and vegetables, but no evidence of increased consumption was found (Bell et al. 2020). Price manipulation and promotion could increase the intake of healthier options – for example, fruits and vegetables – and contribute to healthy body weights (Pehlke et al. 2016; Adam and Jensen 2016; Ries 2013). Price reduction strategies in theory could be very effective to promote healthy food consumption at the consumer end, but feasibility may be limited from a business model perspective where profitability needs to be considered (Noormohamed et al. 2012).

Food package labelling emerged as a potentially effective intervention to reduce the prevalence of overweight and obesity. A study focusing on India found that food labelling providing clear and understandable information about unhealthy foods contributed to the reduction of childhood obesity (Bhattacharya, Saleem, and Bera 2022). Several studies from Latin America found a positive relationship between the adoption of warning labels (if the food exceeds a threshold for calories, added sugars, fats, etc.) and reduction of obesity and obesity-related costs (Basto-Abreu et al. 2020; Pérez-Escamilla et al. 2021). Nutrition labelling that provides general nutrition information on foods and menus is considered less effective than labelling focusing on the negative impacts of unhealthy foods (Bonsmann and Wills 2012).

When it comes to restrictions on advertisements, several studies revealed that restrictions on advertisements for unhealthy food targeting children can play a role in tackling obesity among children (Campbell 2020; Aquino-Vivanco et al. 2013) and is highly cost-effective (Lobstein et al. 2020).

Evidence on a number of food item-driven interventions was found: A study by Arnarson et al. (2011) indicated that salt- and fat-reduced meat products are well accepted by potential consumers and can be successfully used in weight loss programmes. Mvitu Muaka et al. (2010) showed that cassava leaves and dried red beans, rich in antioxidants, can help reduce the risk of metabolic syndrome and hence contribute to obesity prevention.

Findings from the country mapping revealed that the main intervention strategies identified in the transport, trade and processing subsystem related to: strengthening regulations and food standards to reduce use of unhealthy ingredients in the processing stage (sugar/sweetener, sodium, trans fats, etc.); increased market supply of fortified foods with adequate micronutrients; food labelling practices (in local language) to create awareness about unhealthy ingredients; and updating and revision of food composition tables to include “modern” processed foods, and particularly imported food (Herens et al. 2023, forthcoming).

Box 11. Nutrition facts labelling

In Egypt, nutrition facts labels are mandatory. They are provided by the National Food Safety Authority with the aim to better inform consumers on food choices based on science-based facts about the nutritional ingredients (Sedky 2021; National Nutrition institute 2021). In Indonesia, food labelling is also mandatory. Producers and retailers are required to provide a list of the nutrient content of pre-packaged food products and may not make any nutrition or health claims. The Control of Claims on Processed Food Labeling and Advertisements establishes rules on the use of specific nutrient content claims (e.g. levels of fat for a low-fat claim) and sets out certain exceptions. Generally, any nutrition or health claim may only be used on processed foods or beverages if they do not exceed a certain level of fat and sodium per serving.⁸

The evidence in the literature on intervention strategies mainly points to pricing and regulatory intervention mechanisms (tax measures, labelling and adverts) to influence consumers' motives for food choice – an identified driver of overweight/obesity. The practice-based evidence covers very similar interventions but additionally points to diet-based interventions, highlighting more specifically **diet quality** and moderation of **high-energy food intake** (table 2).

Food environment

The intervention strategies aimed at addressing overweight and obesity in the food environment found in the literature review are mainly related to the school food environment and aim to improve children's dietary behaviour and BMI in HICs and LMICs. Less evidence was found related to non-school food environments. Based on the literature review, selected intervention strategies on overweight and obesity in the food environment mainly related to: providing diversified diets in schools (Tao et al. 2020); game-based education (Evans et al. 2015); creating healthy eating zones around schools (Gittelsohn and Kumar 2007); interventions targeting takeaways from restaurants (Perepezko et al. 2018); school-based interventions with the engagement of teachers, families and communities (Evans et al. 2015; Lee et al. 2022; Norman et al. 2016; Varagiannis et al. 2021); and large, community-based multilevel, multi-component interventions (Redmond et al. 2021; Robinson et al. 2021) engaging a variety of stakeholders, including retail (store owners), policy, schools, worksites and the home environment.

Greening et al. (2011) looked into a healthy lifestyle school-based obesity intervention in the United States and found a statistically significant decrease in the percentage of body fat. Gezmen-Karadağ et al. (2019) demonstrated the importance of designing education programmes about nutrition policies targeting school teachers in Turkey. Hadi et al. (2019) proved that the peer nutrition education in schools in India brought about a change in children's nutritional behaviour and could be used for childhood obesity prevention. Evans et al. (2015) stated that school-based interventions across HICs and MICs are cost-effective for reducing obesity risk in children because large numbers of children can be targeted with one school programme. Adding community-based interventions to school- and family-based approaches can strengthen the overall effectiveness of intervention programmes (Filbert et al. 2009). This requires involvement from the government through enforcement and continuous supervision of compliance with regulations (Pineda, Bascunan, and Sassi 2021).

Findings from the country mapping reveal that interventions in the school environment are commonly found, alongside other examples of setting-specific interventions such as community- and workplace-based interventions and public campaigns (Herens et al. 2023, forthcoming). Comparing the evidence from the literature review with the practice-based evidence from the country mapping, considerable alignment can be noted relating to the emphasis placed on school environments as a commonly targeted and preferred setting for addressing overweight and obesity (table 2). Generally, collective approaches are advocated for targeting the social environments of children, by connecting the school environment with the family and community. In particular, referral schemes for obese children are grounded in collaborative efforts between

⁸ See <https://www.nourishglobalnutrition.com/>.

schools and families, and also connected to the health system. Some evidence also points to physical environment interventions, such as school gardens and defining healthy eating zones.

Other practice-based food environment intervention strategies related to food availability and access for selected groups, particularly food subsidy programmes put into place as social safety nets to ensure food security, or interventions providing information and guidelines, such as food-based dietary guidelines, which were identified in all countries. The need for supportive policy conditions to support and endorse the implementation of interventions emerged in both the literature and the evidence from the country mapping. Effective obesity interventions should include multiple integrated components involving a variety of stakeholders (Koletzko et al. 2020). Multisectoral collaboration and advocacy strategies emerged as key ingredients in support of the development of national policy planning on food and nutrition security.

The main food system drivers of these intervention strategies relate to the **access, availability, affordability and acceptability of healthy food**, improving **diet quality**, influencing **motives for food choice** and, in particular, moderating the impact of the **convenience and prestige of junk food**.

Box 12. Food-based dietary guidelines

The most recent food-based dietary guidelines in all selected countries were developed with the support of FAO,⁹ such as the Zambian and Indonesian guidelines, which were developed by building on consultative efforts in the country and on scientifically proven recommendations on diet and a healthy lifestyle, including physical activity recommendations and guidelines for addressing overweight and obesity, to prevent and reduce the risk of NCDs while meeting nutrient and energy requirements.¹⁰

Consumer behaviour

Intervention strategies identified on overweight and obesity mainly related to nutrition education and awareness-raising for behaviour change with respect to dietary choice and physical activities (Varagiannis et al. 2021; Eldridge et al. 2016); personalized nutrition through digital apps (Hu et al. 2020); and maternal education for (first-time) mothers as a strategy to prevent obesity (Uesugi et al. 2016). Leroy et al. (2014) found that the negative effects of household wealth on the prevalence of double-burden households in rural Mexico were effectively mitigated by maternal schooling.

Findings from the country mapping revealed that the main intervention strategies relating to consumer behaviour were mostly generic on healthy diets and dietary practices and not directly addressing overweight and obesity (Herens et al. 2023, forthcoming). For example, awareness-raising interventions about what food to acquire and where varied from broad campaigns for the wider public to setting up specific integrated health and well-being programmes in the workplace, and community- and household-based intervention strategies. The countries also implemented interventions promoting good practices in food handling, with a particular focus on dietary moderation (sugar, salt and fat), and interventions raising awareness on the impact of food and lifestyle choices, generally focusing on integrated interventions on weight reduction combined with sports and physical activity.

⁹ See <https://www.fao.org/nutrition/education/food-based-dietary-guidelines>.

¹⁰ See <https://www.nourishglobalnutrition.com/zambia>.

Box 13. Egypt's cross-sector commitment to address overweight and obesity

Examples of intervention strategies on overweight and obesity in the workplace and the private sector were found in Egypt. The National Nutrition Institute provides advice and guidelines for healthy corporate menus for employees. A few organizations have launched programmes for employees to improve their health and wellness, including fitness campaigns and programmes to promote healthy eating and physical activity as part of their corporate social responsibility. In addition, intervention strategies from the private sector were found relating to the development and implementation of business ideas for healthy catering, applying general fitness programmes and certifying fitness trainers. This is increasingly considered as an interesting business model creating potential for employment (Shahin 2015).

Box 14. Guidance in food preparation in Nigeria

Examples of this type of intervention strategy relate to raising awareness and messaging about dietary moderation: use of added sugar, salt, fat and oil in food preparation. These interventions generally build on or use the national food-based dietary guidelines. In Nigeria, it was flagged that changing cooking practices in this direction often goes hand in hand with discouraging traditional cooking methods, which needs to be considered with caution, as it might put pressure on the gastronomic and cultural values of food.

Comparing the evidence from the literature review with the practice-based evidence from the country mapping, considerable alignment can be noted relating to the emphasis placed on behaviour change campaigns on nutrition education and the promotion of sports and physical activity, delivered either as nationwide programmes targeting the general public or as setting-specific programmes targeting communities, workplaces or businesses (table 2). The main drivers of these intervention strategies relate in part to **diet quality** and **consumption of unhealthy food**, but more often to sociocultural drivers, such as **existing perceptions of healthy body shapes**, and **access to and acceptability of physical activity**, and demographic drivers such as **household wealth, maternal education and motives for food choice**.

Examples of practice-based consumer behaviour intervention strategies also included interventions on food consumption: monitoring consumption patterns and food preparation, and offering guidance to people in choosing healthier options when cooking, relating to the drivers of **diet quality, consumption of unhealthy foods, and motives for food choice**.

Table 2. Food system interventions identified in the comprehensive literature review and the country mapping

Food system element	Interventions identified	Comprehensive literature review	Country mapping	Related drivers*
Food supply chain: production	Production and consumption of lentils	✓		<ul style="list-style-type: none"> • Diet quality • Food availability • Pricing • Environmental contamination
	Nutrition-sensitive agriculture for improved dietary diversity, including promotion of vegetable and fruit production, traditional food production and organic production		✓	
	Household production through homestead and kitchen gardens		✓	
	Bio-fortified food production, including vitamin A (maize, cassava, sweet potato), zinc, iron, other (wheat, rice)		✓	
Food supply chain: transport, trade, processing and sales	Product taxation of sugar-sweetened beverages	✓	✓	<ul style="list-style-type: none"> • Pricing • Diet quality • High-energy diets • Motives for food choice
	Food package labelling, including reviewing food and nutrition facts labelling	✓	✓	
	Update food composition tables to include "new" processed foods		✓	
	Price reduction of healthy foods	✓		
	Regulation of advertising	✓		
	Salt- and fat-reduced meat products	✓		
	Cassava leaves and dried red beans	✓		
	Regulations and food standards for reducing salt, sugar and (trans) fats		✓	
	Product fortification (iron in bread, vitamin A in [palm] oil)		✓	
Food environment	Providing for dietary diversity in schools, including school feeding and school-based interventions with teachers and parents	✓	✓	<ul style="list-style-type: none"> • Diet quality • High-energy diets • Convenience and/or prestige of junk food • Motives for food choice • Affordability of (healthy) food • Increase in food supply • Policy inertia
	Healthy eating zones around schools	✓		
	Information and guidelines for school environments	✓	✓	
	Game-based education in schools	✓		
	School gardening programmes		✓	
	Referral schemes for obese children		✓	
	Food availability and access to food for selected groups/food subsidies		✓	
	Food-based dietary guidelines		✓	
	Large, community-based multilevel, multi-component interventions	✓		
Multisectoral policy, action and advocacy		✓		
Consumer behaviour	Nutrition education with respect to dietary choice, including public campaigns, workplace campaigns	✓	✓	<ul style="list-style-type: none"> • Diet quality • Unhealthy food • Motives for food choice • Sociocultural drivers (perceptions of healthy body shapes, of physical activity, of unhealthy food), demographic (household wealth, maternal education), nutrition (maternal BMI)
	Awareness-raising for behaviour change with respect to dietary choice and physical activities	✓	✓	
	Consumption surveys		✓	
	Healthy lifestyles as an emerging business opportunity		✓	
	Community interventions		✓	
	Guidance in food preparation for dietary moderation		✓	

* As identified in the comprehensive literature review.

4. Discussion and conclusions

4.1. Discussion

While the literature review was able to provide insight into the drivers, causes and interventions to address overweight and obesity, it also sheds light on the evidence gaps that exist. Some of these gaps in the body of scientific evidence that could be filled by future research include:

- Food environment and food choice research in LMICs, including the full spectrum of diets, nutritional status and health outcomes. A better understanding of the sociocultural determinants of food choices and physical activity could help identify opportunities to make environments less obesogenic.
- The specific dimensions of overweight and obesity among rural populations (as opposed to more urban populations) are not yet well understood. It is hypothesized that the causes of overweight and obesity in urban areas are permeating rural areas as countries develop economically. Drivers such as changing infrastructure, transportation, employment, income, food access and physical activity are becoming more prevalent in rural areas too. Additionally, there may be drivers that are specific to rural areas, such as exposure to environmental contaminants through agriculture, and the likelihood of becoming a food desert due to remoteness. More data and research are needed to answer these hypotheses.

The document review for the country mapping provided a wealth of general nutrition information, but in most cases little evidence that the identified policies, interventions and programmes are effective in addressing overweight and obesity. The stakeholder consultation process further helped to identify the relevant documentation and intervention approaches applied in the country. It should be noted that the lack of documented evidence does not mean that interventions are ineffective; rather, it means that there is no evidence (found in this mapping) to prove effectiveness.

Some notable weaknesses and gaps are:

- There is a lack of updated nutritional information at the national or local level, which does not allow in-depth analysis and strategic decision-making to address malnutrition in all its forms.
- Overweight and obesity are surfacing on the national NCD agendas in their capacity of modifiable behavioural risk factor to NCD development, but specific indicators or targets are often not defined, or defined as no rise since a baseline year.
- The nutrition strategies that the agricultural sector pursues do not always specify whether they aim to address undernutrition, overnutrition or both. Where addressing overnutrition is mentioned as an objective, the pathways that link access to healthy foods and overnutrition are not defined or described explicitly.
- The few examples of existing programmatic interventions tackling overweight and obesity through agriculture and food systems transformation target food marketing and processing, such as food labelling, with a focus on raising awareness on the nutrient content of foods. Given that overweight and obesity seem driven by low educational levels and a lack of health literacy, the effectiveness of these strategies remains to be seen.

4.2. Concluding comments

This paper aimed to address two main research questions:

What are the drivers and causes of overweight and obesity in the food systems in the context of rural areas in LMICs?

Overweight and obesity are products of an obesogenic food system. This review shows just how systemic an issue overweight and obesity is, with drivers being present in nearly each component of the food system. It helps to explain why addressing overweight and obesity at an individual level is so difficult, and why there are few interventions so far that have proven effective.

The direct cause of overweight and obesity is an energy imbalance: more energy is consumed than expended. Physical activity, through which energy is expended, is becoming less of a requirement for daily life, partly due to technological innovations ranging from motorized transport to the television. Meanwhile (and likely more importantly), diets are delivering too many calories, and can be of poor quality. These diets are the output of modern, global food supply chains which favour (ultra-)processed foods, energy-dense staples, use of caloric sweeteners in foods (especially beverages), and the use of vegetable oil. Food environments, where consumers interact with the food supply chain, can drive consumption of energy-dense foods if they make these foods available, affordable, acceptable, promoted and safe. Generally, energy-dense foods tend to be cheaper than their more nutritious counterparts. A special category of factors contains nutrition and health outcomes in themselves, while also being drivers for overweight in the future or among offspring. These are maternal BMI and diet, weight gain during pregnancy, birth weight, exclusive breastfeeding and rate of infant weight gain, and the gut microbiome.

The main drivers of overweight and obesity identified in the country mapping included food insecurity, urbanization, dietary and lifestyle transition, socio-economic (income, education) and cultural factors, wealth status, obesogenic diets and poor dietary diversity, lack of physical activity, and poor maternal, foetal and infant nutrition. Gender-related differences are manifest – in particular, adult women being more often overweight or obese than their male peers. In-country differences were reported (in particular, in Bolivia and Egypt), but how geographical factors influence overweight and obesity is not further explored. Although the main drivers appear the same at first glance, countries seem to differ in how much a particular driver matters. The country mapping reveals that the increased prevalence of overweight and obesity in rural areas is not yet recognized as a unique pattern, in need of further exploration and a clear research and intervention agenda, because it goes against the common understanding of viewing urbanization as a major driver of the rise in BMI and overweight and obesity rates worldwide.

What evidence is available on intervention strategies with the potential to prevent and/or reduce overweight and obesity in the different areas of the food system?

We aimed to provide an overview of the overweight and obesity intervention strategies that have been proven to be potentially effective in mitigating the overweight and obesity problems in LMICs. Due to the limited number of papers that specifically address LMICs, we also included some literature focusing on HICs.

The results show that food system-related interventions are still applying traditional approaches such as food package labelling, price manipulation and changing the food environment. There is a lack of food value chain approaches to address the problem of overweight and obesity from a post-harvest management perspective (e.g. post-harvest handling, storage, transportation), which makes it difficult to unpack value chain impacts on overweight and obesity. Achieving a healthier food environment is crucial to reduce overweight and requires the engagement of governments and policymakers, as well as intersectoral collaboration. For food environment interventions, behaviour change strategies such as nutrition education and awareness-raising play a key role in combating overweight. This requires an integrated multilevel, multi-component approach with school-, family- and community-based programmes because none of the individual interventions can solve the problem on its own.

Looking at the linkages between the drivers and the interventions identified in the literature review, some are closely aligned (directly or indirectly) with each other, and some are not. Some of the intervention strategies identified are directly connected to a specific driver. For example, taxation is a widely used measure to reduce the use of added sugars, especially in sugar-sweetened beverages, identified as a driver in this research. The same applies to advertising restrictions targeting the driver of promotion of unhealthy foods. There are also interventions targeting multiple drivers. For example, school-based nutrition education and awareness-raising programmes aim to improve the knowledge of teachers, students and parents to change their behaviour with regard to dietary choice and physical activity, which are affected by multiple sociocultural, dietary and consumer behaviour drivers. The linkages between some drivers and interventions are somewhat

weak because of intervenable drivers (e.g. income growth, technology advancement, urbanization), a lack of clarity about the (mechanisms of) causality and correlations (e.g. income equality and overweight prevalence), and trade-offs between contradictory policy goals (e.g. market development and overweight prevention).

Overall, there is a critical need to build an evidence base of the drivers of overweight and obesity, as well as interventions and strategies to address the problem in LMICs. This would require robust monitoring and evaluation to assess the impact of the interventions, as well as to understand if the intervention logic is correct, and sharing of these assessments. There is a need to develop appropriate research approaches to study the effectiveness of interventions, given the multilevel and systemic nature of overweight and obesity, as well as proper investment and political will to build the evidence.

The interventions found aimed to making diets healthier; however, they did not have objectives related to the management or prevention of overweight and obesity. Future interventions should have specific objectives related to overweight and obesity and should measure and report on their effectiveness. This would be helpful to act on the growing pandemic and start accumulating evidence on what works and what does not work in terms of overweight and obesity management/prevention.

Two of the reasons that make it important to take action now to prevent overweight and obesity in LMICs include: (i) LMICs witnessed an ongoing increase in overweight and obesity from 1975 to 2016 (WHO 2017), even though it has not reached the prevalence in HICs; if no action is taken, the prevalence is likely to continue increasing, affecting both rural and urban populations; and (ii) one of the goals of international development, nutrition-sensitive interventions and government is to improve livelihoods and reduce poverty. However, in LMICs, increased wealth is associated with an increased likelihood of overweight and obesity (Subramanian et al. 2010); therefore, efforts should be made to ensure the positive effect of increased household income does not translate into health risks resulting from overweight and obesity.

Taking action to prevent overweight and obesity includes integrating overweight and obesity prevention activities in food systems and nutrition-sensitive programmes. This can be done by raising awareness of the health risks of overweight and obesity, providing education on how to prevent it, and addressing the cultural appreciation of overweight and obesity. Moreover, it is critical that governments make policies to regulate food systems to make them less obesogenic. These policies could include regulating the food market (making regulations that favour the production of healthy products) and making healthy foods more affordable than unhealthy ones.

References

- Abay, K.A., Ibrahim, H., Breisinger, C. and Bayasgalanbat, N. 2020. *Food Policies and their Implications on Overweight and Obesity: Trends in Selected Countries in the Near East and North Africa Region*. Rome: Food and Agriculture Organization of the United Nations.
<https://www.fao.org/3/cb2338en/CB2338EN.pdf>
- Adam, A., and Jensen, J.D. 2016. What is the effectiveness of obesity related interventions at retail grocery stores and supermarkets? - a systematic review. *BMC Public Health* 16(1): 1-18.
<https://doi.org/10.1186/s12889-016-2823-5>
- Aizawa, T., and Helble, M. 2017. Socioeconomic Inequality in Excessive Body Weight in Indonesia. *Economics & Human Biology*, 27. <https://doi.org/10.1016/j.ehb.2017.09.005>
- Allen, S., and de Brauw, A. 2018. Nutrition sensitive value chains: Theory, progress, and open questions. *Global Food Security* 16: 22-28. <https://doi.org/10.1016/j.gfs.2017.07.002>
- Allison, D.B., Kaprio, J., Korkeila, M., Koskenvuo, M., Neale, M.C. and Hayakawa, K. 1996. The heritability of body mass index among an international sample of monozygotic twins reared apart. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 20(6): 501-506.
- Aquino-Vivanco, Ó., Aramburu, A., Munares-García, Ó., Gómez-Guizado, G., García-Torres, E., Donaires-Toscano, F. and Fiestas, F. 2013. Interventions to control overweight and obesity in children and adolescents in Peru Intervenciones para el control del sobrepeso y obesidad en niños y adolescentes en el Perú. *Revista Peruana de Medicina Experimental y Salud Publica* 30(2): 275-282. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84882646305&partnerID=40&md5=599aa96a8500e92ea1ed9e7db848d923>
- Arnarson, A., Olafsdottir, A., Ramel, A., Martinsdottir, E., Reykdal, O., Thorsdottir, I. and Thorkelsson, G. 2011. Sensory analysis and consumer surveys of fat- and salt-reduced meat products and their use in an energy-reduced diet in overweight individuals. *International Journal of Food Sciences and Nutrition* 62(8): 872-880. <https://doi.org/10.3109/09637486.2011.589376>
- Baker, P., Machado, P., Santos, T., Sievert, K., Backholer, K., Hadjidakou, M. and Scrinis, G. 2020. Ultra-processed foods and the nutrition transition: Global, regional and national trends, food systems transformations and political economy drivers. *Obesity Reviews* 21(12): e13126.
<https://doi.org/10.1111/obr.13126>
- Basto-Abreu, A., Torres-Alvarez, R., Reyes-Sánchez, F., González-Morales, R., Canto-Osorio, F., Colchero, M.A. and Barrientos-Gutierrez, T. 2020. Predicting obesity reduction after implementing warning labels in Mexico: A modeling study. *PLoS Medicine* 17(7).
<https://doi.org/10.1371/journal.pmed.1003221>
- Bell, C., Latu, C., Coriakula, J., Waqa, G., Snowdon, W. and Moodie, M. 2020. Fruit and vegetable import duty reduction in Fiji to prevent obesity and non-communicable diseases: A case study. *Public Health Nutrition* 23(1): 181-188. <https://doi.org/10.1017/S1368980019002660>
- Bhattacharya, S., Saleem, S.M. and Bera, O.P. 2022. Prevention of childhood obesity through appropriate food labeling. *Clinical Nutrition ESPEN* 47: 418-421.
<https://doi.org/10.1016/j.clnesp.2021.12.010>
- BKKBN, BPS, Kemenkes, and ICF. 2018. *Indonesia Demographic and Health Survey 2017*. Jakarta: National Population and Family Planning Board, Statistics Indonesia, Ministry of Health, and ICF.
<http://dhsprogram.com/pubs/pdf/FR342/FR342.pdf>
- Bonsmann, S. and Wills, J.M. 2012. Nutrition Labeling to Prevent Obesity: Reviewing the Evidence from Europe. *Current Obesity Reports* 1(3): 134-140. <https://doi.org/10.1007/s13679-012-0020-0>
- Cabrera Escobar, M.A., Veerman, J.L., Tollman, S.M., Bertram, M.Y. and Hofman, K.J. 2013. Evidence that a tax on sugar sweetened beverages reduces the obesity rate: A meta-analysis. *BMC Public Health* 13(1). <https://doi.org/10.1186/1471-2458-13-1072>

- Campbell, M. 2020. NCD prevention and international investment law in latin America: Chile's experience in preventing obesity and unhealthy diets. *Journal of World Investment and Trade* 21(5): 781-808. <https://doi.org/10.1163/22119000-12340195>
- Castillo-Laura, H., Santos, I.S., Quadros, L. and Matijasevich, A. 2015. Maternal obesity and offspring body composition by indirect methods: a systematic review and meta-analysis. *Cadernos de saude publica* 31: 2073-2092. <https://doi.org/10.1590/0102-311X00159914>
- Coa, R. and Ochoa, L.H. 2009. *Bolivia Encuesta Nacional de Demografía y Salud 2008*. Calverton, Maryland, USA: Ministerio de Salud y Deportes and Macro International. <http://dhsprogram.com/pubs/pdf/FR228/FR228.pdf>
- Crino, M., Sacks, G., Vandevijvere, S., Swinburn, B. and Neal, B. 2015. The influence on population weight gain and obesity of the macronutrient composition and energy density of the food supply. *Current Obesity Reports* 4(1): 1-10. <https://doi.org/10.1007/s13679-014-0134-7>
- De Brauw, A., van den Berg, M., Brouwer, I., Snoek, H., Vignola, R., Melesse, M. and Ruben, R. 2019. *Food System Innovations for Healthier Diets in Low and Middle-Income Countries*. Research Report. Washington, DC: International Food Policy Research Institute.
- Development Initiatives. 2017. *Global Nutrition Report 2017: Nourishing the SDGs*. Bristol, UK: Development Initiatives. https://globalnutritionreport.org/documents/822/Global_Nutrition_Report_2017.pdf
- Development Initiatives. 2018. *2018 Global Nutrition Report: Shining a light to spur action on nutrition*. Bristol, UK: Development Initiatives. https://globalnutritionreport.org/documents/352/2018_Global_Nutrition_Report.pdf
- Development Initiatives. 2020. *Global Nutrition Report 2020: Action on equity to end malnutrition*. Bristol, UK. https://globalnutritionreport.org/documents/566/2020_Global_Nutrition_Report_2hrssKo.pdf
- Dobbs, R., Sawers, C., Thompson, F., Manyika, J., Woetzel, J., Child, P. and Spatharou, A. 2014. Overcoming obesity: An initial economic analysis. McKinsey & Company. https://www.mckinsey.com/~media/mckinsey/business%20functions/economic%20studies%20temp/our%20insights/how%20the%20world%20could%20better%20fight%20obesity/mgi_overcoming_obesity_full_report.ashx
- Drewnowski, A. and Popkin, B.M. 1997. The nutrition transition: new trends in the global diet. *Nutrition Reviews* 55(2): 31-43. <https://doi.org/10.1111/j.1753-4887.1997.tb01593.x>
- Driessen, C.E., Cameron, A.J., Thornton, L.E., Lai, S.K. and Barnett, L.M. 2014. Effect of changes to the school food environment on eating behaviours and/or body weight in children: a systematic review. *Obesity Reviews* 15(12): 968-982. <https://doi.org/10.1111/obr.12224>
- Eldridge, G., Paul, L., Bailey, S.J., Ashe, C.B., Martz, J. and Lynch, W. 2016. Effects of parent-only childhood obesity prevention programs on BMIz and body image in rural preteens. *Body Image* 16: 143-153. <https://doi.org/10.1016/j.bodyim.2015.12.003>
- Evans, C.E.L., Albar, S.A., Vargas-Garcia, E.J. and Xu, F. 2015. School-Based Interventions to Reduce Obesity Risk in Children in High- and Middle-Income Countries. *Advances in Food and Nutrition Research* 76: 29-77. <https://doi.org/10.1016/bs.afnr.2015.07.003>
- FAO. 2023. Food balances (2010-). Food and Agriculture Organization of the United Nations. <https://www.fao.org/faostat/en/#data/FBS>.
- FAO. n.d. Sustainable Agricultural Mechanization – Why mechanization is important. Food and Agriculture Organization of the United Nations. <https://www.fao.org/sustainable-agricultural-mechanization/overview/why-mechanization-is-important/en/>
- Federal Republic of Nigeria. 2017. *Agricultural Food Security and Nutrition Strategy 2016-2025*. Abuja: Federal Republic of Nigeria. https://nipc.gov.ng/wp-content/uploads/2020/11/Agriculture-FSN-Strategy-2016-25_Printed-Version_1562696265.pdf?
- Federal Republic of Nigeria. 2019. *National Multi-Sectoral Action Plan for the Prevention and Control of Non-Communicable Diseases (2019-2025)*. Abuja: Federal Republic of Nigeria. https://www.iccp-portal.org/system/files/plans/NCDs_Multisectoral_Action_Plan.pdf

- Filbert, E., Chesser, A., Hawley, S.R. and St. Romain, T. 2009. Community-based participatory research in developing an obesity intervention in a rural county. *Journal of Community Health Nursing* 26(1): 35-43. <https://doi.org/10.1080/07370010802605804>
- Ford, N.D., Patel, S.A. and Narayan, K.M.V. 2017. Obesity in Low- and Middle-Income Countries: Burden, Drivers, and Emerging Challenges. *Annual Review of Public Health* 38: 145-164. <https://doi.org/10.1146/annurev-publhealth-031816-044604>
- Fruhstorfer, B.H., Mousoulis, C., Uthman, O.A. and Robertson, W. 2016. Socio-economic status and overweight or obesity among school-age children in sub-Saharan Africa - a systematic review. *Clinical Obesity* 6(1): 19-32. <https://doi.org/10.1111/cob.12130>
- Gezmen-Karadağ, M., Yildiran, H., Köksal, E. and Ertaş Öztürk, Y. 2019. School Teachers' Awareness about National Obesity Prevention Programs in Turkey. *Ecology of Food and Nutrition* 58(5): 470-480. <https://doi.org/10.1080/03670244.2019.1617706>
- Gittelsohn, J. and Kumar, M.B. 2007. Preventing childhood obesity and diabetes: Is it time to move out of the school? *Pediatric Diabetes* 8(Suppl. 9): 55-69. <https://doi.org/10.1111/j.1399-5448.2007.00333.x>
- Global Food Research Program . (2021). *Ultra-processed foods: A global threat to public health*. Factsheet. Chapel Hill, NC, USA: University of North Carolina at Chapel Hill. <https://www.globalfoodresearchprogram.org/resources/fact-sheets/>
- Goris, J.M., Petersen, S., Stamatakis, E. and Veerman, J.L. 2010. Television food advertising and the prevalence of childhood overweight and obesity: a multicountry comparison. *Public Health Nutrition* 13(7): 1003-1012. <https://doi.org/10.1017/S1368980009992850>
- Goryakin, Y. and Suhrcke, M. 2014. Economic development, urbanization, technological change and overweight: What do we learn from 244 Demographic and Health Surveys? *Economics & Human Biology* 14: 109-127. <https://doi.org/10.1016/j.ehb.2013.11.003>
- Greening, L., Harrell, K.T., Low, A.K. and Fielder, C.E. 2011. Efficacy of a school-based childhood obesity intervention program in a rural southern community: TEAM Mississippi Project. *Obesity* 19(6): 1213-1219. <https://doi.org/10.1038/oby.2010.329>
- Grün, F. and Blumberg, B. 2006. Environmental obesogens: organotins and endocrine disruption via nuclear receptor signaling. *Endocrinology*, 147(6 Suppl.): S50-55. <https://doi.org/10.1210/en.2005-1129>
- Hadi, A.J., Hadju, V., Suriah, Indriasari, R., Sudargo, T., Nyorong, M. and Masni. 2019. Model of peer intervention assessment of nutritional educator in the efforts to change behaviour in decreasing overweight in integrated Islamic elementary schools at Makassar. *Indian Journal of Public Health Research and Development* 10(9): 613-618.
- Hall, K.D. 2018. Did the food environment cause the obesity epidemic? *Obesity* 26(1): 11-13. <https://doi.org/10.1002/oby.22073>
- Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., Ekelund, U. and Group LPASW. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 380(9838): 247-257. [https://doi.org/10.1016/S0140-6736\(12\)60646-1](https://doi.org/10.1016/S0140-6736(12)60646-1)
- Headey, D.D. and Alderman, H.H. 2019. The Relative Caloric Prices of Healthy and Unhealthy Foods Differ Systematically across Income Levels and Continents. *The Journal of Nutrition* 149(11): 2020-2033. <https://doi.org/10.1093/jn/nxz158>
- Herens, M., ten Hove, H. and Perez Cardona, O. 2023 (forthcoming). *Overweight and obesity in LMICs in the realm of rural development and food systems: a country mapping*. Wageningen, Netherlands: Wageningen University and Research, Wageningen Centre for Development Innovation
- Herforth, A. and Ahmed, S. 2015. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security* 7(3): 505-520. <https://doi.org/10.1007/s12571-015-0455-8>
- Herforth, A., Bai, Y., Venkat, A., Mahrt, K., Ebel, A. and Masters, W.A. 2020. *Cost and affordability of healthy diets across and within countries*. Background paper for The State of Food Security and

- Nutrition in the World 2020. FAO Agricultural Development Economics Technical Study No. 9. Rome: Food and Agriculture Organization of the United Nations. <https://doi.org/10.4060/cb2431en>
- Herrera, B.M., Keildson, S. and Lindgren, C.M. 2011. Genetics and epigenetics of obesity. *Maturitas* 69(1): 41-49. <https://doi.org/10.1016/j.maturitas.2011.02.018>
- HLPE. 2015. *Water for food security and nutrition*. Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. https://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-9_EN.pdf
- HLPE. 2017. *Nutrition and food systems*. Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. <https://www.fao.org/3/i7846e/i7846e.pdf>
- HLPE. 2020. *Food security and nutrition: building a global narrative towards 2030*. Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. <http://www.fao.org/3/ca9731en/ca9731en.pdf>
- Hu, E.A., Nguyen, V., Langheier, J. and Shurney, D. 2020. Weight reduction through a digital nutrition and food purchasing platform among users with obesity: Longitudinal study. *Journal of Medical Internet Research* 22(9). <https://www.jmir.org/2020/9/e19634/>
- Itria, A., Borges, S.S., Rinaldi, A.E.M., Nucci, L.B. and Enes, C.C. 2021. Taxing sugar-sweetened beverages as a policy to reduce overweight and obesity in countries of different income classifications: A systematic review. *Public Health Nutrition*. <https://doi.org/10.1017/S1368980021002901>
- Jaacks, L.M., Slining, M.M. and Popkin, B.M. 2015a. Recent trends in the prevalence of under-and overweight among adolescent girls in low-and middle-income countries. *Pediatric Obesity* 10(6): 428-435. <https://doi.org/10.1111/ijpo.12000>
- Jaacks, L.M., Slining, M.M. and Popkin, B.M. 2015b. Recent underweight and overweight trends by rural–urban residence among women in low-and middle-income countries. *The Journal of Nutrition* 145(2): 352-357. <https://doi.org/10.3945/jn.114.203562>
- Jaacks, L.M., Kavle, J., Perry, A. and 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. *Public Health Nutrition* 20(7): 1286-1296. <https://doi.org/10.1017/S1368980016003323>
- Jones-Smith, J.C., Gordon-Larsen, P., Siddiqi, A. and Popkin, B.M. 2011. Cross-national comparisons of time trends in overweight inequality by socioeconomic status among women using repeated cross-sectional surveys from 37 developing countries, 1989–2007. *American Journal of Epidemiology* 173(6): 667-675. <https://doi.org/10.1093/aje/kwq428>
- Kanter, R. and Caballero, B. 2012. Global gender disparities in obesity: a review. *Advances in Nutrition* 3(4): 491-498. <https://doi.org/10.3945/an.112.002063>
- Karanja, A., Ickowitz, A., Stadlmayr, B. and McMullin, S. 2022. Understanding drivers of food choice in low- and middle-income countries: A systematic mapping study. *Global Food Security* 32: 100615. <https://doi.org/10.1016/j.gfs.2022.100615>
- Kennedy, G., Nantel, G. and Shetty, P. 2004. *Globalization of food systems in developing countries: impact on food and nutrition security*. Nutrition Paper No. 83. Rome: Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/y5736e/y5736e.pdf>
- Koletzko, B., Fishbein, M., Lee, W.S., Moreno, L., Mouane, N., Mouzaki, M. and Verduci, E. 2020. Prevention of Childhood Obesity: A Position Paper of the Global Federation of International Societies of Paediatric Gastroenterology, Hepatology and Nutrition (FISPGHAN). *Journal of Pediatric Gastroenterology and Nutrition* 70(5): 702-710. doi:10.1097/mpg.0000000000002708.
- Lee, J.A.C., Cheah, W.L., Anchang, G.N.J., Noor Hafizah, Y., Abim, M., Ruzita, A.T. and Gibson, E.L. 2022. Teachers' and Parents' Perspectives on the Feasibility of a Preschool-Based Behavioral Intervention to Prevent Obesity: An Embedded Qualitative Study within ToyBox Study Malaysia. *Early Childhood Education Journal*. <https://doi.org/10.1007/s10643-021-01290-2>

- Leroy, J.L., Habicht, J.P., de Cossío, T.G. and Ruel, M.T. 2014. Maternal education mitigates the negative effects of higher income on the double burden of child stunting and maternal overweight in rural Mexico. *Journal of Nutrition* 144(5): 765-770. <https://doi.org/10.3945/jn.113.188474>
- Lobstein, T., Neveux, M. and Landon, J. 2020. Costs, equity and acceptability of three policies to prevent obesity: A narrative review to support policy development. *Obesity Science and Practice* 6(5): 562-583. <https://doi.org/10.1002/osp4.423>
- Malik, V.S. and Hu, F.B. 2022. The role of sugar-sweetened beverages in the global epidemics of obesity and chronic diseases. *Nature Reviews Endocrinology*, 1-14. <https://doi.org/10.1038/s41574-021-00627-6>
- Meyfroidt, P. 2016. Approaches and terminology for causal analysis in land systems science. *Journal of Land Use Science* 11(5): 501-522. <https://doi.org/10.1080/1747423X.2015.1117530>
- Ministry of Health and Population/Egypt, El-Zanaty and Associates/Egypt, and ICF International. 2015. Egypt Demographic and Health Survey 2014. Cairo: Ministry of Health and Population and ICF International. <http://dhsprogram.com/pubs/pdf/FR302/FR302.pdf>
- Monteiro, C.A., Conde, W.L., Lu, B. and Popkin, B.M. 2004. Obesity and inequities in health in the developing world. *International Journal of Obesity* 28(9): 1181-1186. <https://doi.org/10.1038/sj.ijo.0802716>
- Mvitu Muaka, M., Longo-Mbenza, B., Tulomba Mona, D. and Nge Okwe, A. 2010. Reduced risk of metabolic syndrome due to regular intake of vegetables rich in antioxidants among African type 2 diabetics. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews* 4(3): 132-136. <https://doi.org/10.1016/j.dsx.2010.07.003>
- Nakhimovsky, S.S., Feigl, A.B., Avila, C., O'Sullivan, G., MacGregor-Skinner, E. and Spranca, M. 2016. Taxes on sugar-sweetened beverages to reduce overweight and obesity in middle-income countries: A systematic review. *PLoS ONE* 11(9). <https://doi.org/10.1371/journal.pone.0163358>
- National Nutrition Institute. 2021 (forthcoming). *Food Consumption Pattern and Nutrient Intake among the Egyptian Population 2021*. Cairo: National Nutrition Institute.
- NPC and ICF. 2019. *Nigeria Demographic and Health Survey 2018 – Final Report*. Abuja: National Population Commission and ICF. <http://dhsprogram.com/pubs/pdf/FR359/FR359.pdf>
- Noormohamed, A., Lee, S.H., Batorsky, B., Jackson, A., Newman, S. and Gittelsohn, J. 2012. Factors Influencing Ordering Practices at Baltimore City Carryouts: Qualitative Research to Inform an Obesity Prevention Intervention. *Ecology of Food and Nutrition* 51(6): 481-491. <https://doi.org/10.1080/03670244.2012.705732>
- Norman, Å., Nyberg, G., Elinder, L.S. and Berlin, A. 2016. One size does not fit all-qualitative process evaluation of the Healthy School Start parental support programme to prevent overweight and obesity among children in disadvantaged areas in Sweden. *BMC Public Health* 16(1). <https://doi.org/10.1186/s12889-016-2701-1>
- Our World in Data n.d. Share of adults that are obese vs. GDP per capita, 2016 [map]. Our World in Data. <https://ourworldindata.org/grapher/obesity-vs-gdp>
- Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al. 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews* 2021(10): 89.
- Pehlke, E.L., Letona, P., Ramirez-Zea, M. and Gittelsohn, J. 2016. Healthy cassetas: A potential strategy to improve the food environment in low-income schools to reduce obesity in children in Guatemala City. *Ecology of Food and Nutrition* 55(3): 324-338. doi:10.1080/03670244.2016.1161618.
- Perepezko, K., Tingey, L., Sato, P., Rastatter, S., Ruggiero, C. and Gittelsohn, J. 2018. Partnering with carryouts: Implementation of a food environment intervention targeting youth obesity. *Health Education Research* 33(1): 4-13. <https://doi.org/10.1093/her/cyx078>
- Pérez-Escamilla, R., Vilar-Compte, M., Rhodes, E., Sarmiento, O.L., Corvalan, C., Sturke, R. and Vorkoper, S. 2021. Implementation of childhood obesity prevention and control policies in the United






- States and Latin America: Lessons for cross-border research and practice. *Obesity Reviews* 22(S3). <https://doi.org/10.1111/obr.13247>
- Pfinder, M., Heise, T.L., Hilton Boon, M., Pega, F., Fenton, C., Griebler, U. and Lhachimi, S.K. 2020. Taxation of unprocessed sugar or sugar-added foods for reducing their consumption and preventing obesity or other adverse health outcomes. *Cochrane Database of Systematic Reviews* 2020(4). <https://doi.org/10.1002/14651858.CD012333.pub2>
- Pineda, E., Bascunan, J. and Sassi, F. 2021. Improving the school food environment for the prevention of childhood obesity: What works and what doesn't. *Obesity Reviews* 22(2). <https://doi.org/10.1111/obr.13176>
- Popkin, B.M. 2001. The nutrition transition and obesity in the developing world. *The Journal of Nutrition* 131(3): 871S-873S. <https://doi.org/10.1093/jn/131.3.871S>
- Popkin, B.M. 2004. The nutrition transition: an overview of world patterns of change. *Nutrition Reviews* 62(Suppl. 2): S140-S143. <https://doi.org/10.1111/j.1753-4887.2004.tb00084.x>
- Popkin, B.M. and Gordon-Larsen, P. 2004. The nutrition transition: worldwide obesity dynamics and their determinants. *International Journal of Obesity* 28(3): S2-S9. <https://doi.org/10.1038/sj.ijo.0802804>
- Redmond, L.C., Jock, B., Kolahdooz, F., Sharma, S., Pareda, M., Swartz, J. and Gittelsohn, J. 2021. A multi-level, multi-component obesity intervention (Obesity Prevention and Evaluation of InterVention Effectiveness in NaTive North Americans) decreases soda intake in Native American adults. *Public Health Nutrition*. <https://doi.org/10.1017/S1368980020001172>
- Ries, N.M. 2013. What Is the Role of Regulation in the Management and Prevention of Obesity? *Current Obesity Reports* 2(4): 327-332. <https://doi.org/10.1007/s13679-013-0068-5>
- Ritchie, H. and Roser, M. 2017. Obesity [map]. Our World in Data. <https://ourworldindata.org/obesity>
- Robinson, T.N., Matheson, D., Wilson, D.M., Weintraub, D.L., Banda, J.A., McClain, A. and Desai, M. 2021. A community-based, multi-level, multi-setting, multi-component intervention to reduce weight gain among low socioeconomic status Latinx children with overweight or obesity: The Stanford GOALS randomised controlled trial. *The Lancet Diabetes and Endocrinology* 9(6): 336-349. [https://doi.org/10.1016/S2213-8587\(21\)00084-X](https://doi.org/10.1016/S2213-8587(21)00084-X)
- Roemling, C. and Qaim, M. 2012. Obesity trends and determinants in Indonesia. *Appetite* 58(3): 1005-1013. <https://doi.org/10.1016/j.appet.2012.02.053>
- Roser, M., Ritchie, H. and Rosado, P. 2018. Food Supply [map]. Our World in Data. <https://ourworldindata.org/food-supply>
- Sadeghirad, B., Duhaney, T., Motaghipisheh, S., Campbell, N. and Johnston, B. 2016. Influence of unhealthy food and beverage marketing on children's dietary intake and preference: a systematic review and meta-analysis of randomized trials. *Obesity Reviews* 17(10): 945-959. <https://doi.org/10.1111/obr.12445>
- Sedky, A.G., Marwa, G., Magdy, N. and El Safoury, S. 2021. Combating the High Prevalence of Obesity among Egyptian Households: A Pilot Study: Port-Said Households. *Papers, Posters, and Presentations* 91. https://fount.aucegypt.edu/studenttxt/91/?utm_source=fount.aucegypt.edu%2Fstudenttxt%2F91&utm_medium=PDF&utm_campaign=PDFCoverPages
- Shahin, H. 2015. Obesity interventions in Egypt: identifying gaps and highlighting assets. Master's thesis, the American University in Cairo. <https://fount.aucegypt.edu/etds/117>
- Siva, N., Thavarajah, D., Johnson, C.R., Duckett, S., Jesch, E.D. and Thavarajah, P. 2017. Can lentil (*Lens culinaris Medikus*) reduce the risk of obesity? *Journal of Functional Foods* 38: 706-715. <https://doi.org/10.1016/j.jff.2017.02.017>
- Snowdon, W. and Thow, A.M. 2013. Trade policy and obesity prevention: Challenges and innovation in the Pacific Islands. *Obesity Reviews* 14(S2): 150-158. <https://doi.org/10.1111/obr.12090>

- Songsermsawas, T., Mabiso, A., Arslan, A., Chiarella, C. and Savastano, S. 2022. Agricultural value chains and food security in the Pacific: Evidence from Papua New Guinea and Solomon Islands. Under review.
- Subramanian, S., Perkins, J.M., Özaltin, E. and Davey Smith, G. 2010. Weight of nations: a socioeconomic analysis of women in low- to middle-income countries. *The American Journal of Clinical Nutrition* 93(2): 413-421. <https://doi.org/10.3945/ajcn.110.004820>
- Swinburn, B.A., Sacks, G., Hall, K.D., McPherson, K., Finegood, D.T., Moodie, M.L. and Gortmaker, S.L. 2011. The global obesity pandemic: shaped by global drivers and local environments. *Lancet* 378(9793): 804-814. [https://doi.org/10.1016/S0140-6736\(11\)60813-1](https://doi.org/10.1016/S0140-6736(11)60813-1)
- Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R. and Devarajan, R. 2019. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. *Lancet* 393(10173): 791-846. [https://doi.org/10.1016/S0140-6736\(18\)32822-8](https://doi.org/10.1016/S0140-6736(18)32822-8)
- Tao, C., Zhao, Q., Glauben, T. and Ren, Y. 2020. Does dietary diversity reduce the risk of obesity? Empirical evidence from rural school children in China. *International Journal of Environmental Research and Public Health* 17(21): 1-16. <https://doi.org/10.3390/ijerph17218122>
- Turnbaugh, P.J., Backhed, F., Fulton, L. and Gordon, J.I. 2008. Marked alterations in the distal gut microbiome linked to diet-induced obesity. *Cell Host & Microbe* 3(4): 213. <https://doi.org/10.1016/j.chom.2008.02.015>
- Turner, C., Kalamatianou, S., Drewnowski, A., Kulkarni, B., Kinra, S. and Kadiyala, S. 2020. Food environment research in low-and middle-income countries: a systematic scoping review. *Advances in Nutrition* 11(2): 387-397. <https://doi.org/10.1093/advances/nmz031>
- Uesugi, K.H., Dattilo, A.M., Black, M.M. and Saavedra, J.M. 2016. Design of a Digital-Based, Multicomponent Nutrition Guidance System for Prevention of Early Childhood Obesity. *Journal of Obesity* 2016. <https://doi.org/10.1155/2016/5067421>
- Van de Poel, E., O'Donnell, O. and Van Doorslaer, E. 2009. Urbanization and the spread of diseases of affluence in China. *Economics & Human Biology* 7(2): 200-216. <https://doi.org/10.1016/j.ehb.2009.05.004>
- Vandevijvere, S., Chow, C.C., Hall, K.D., Umali, E. and Swinburn, B.A. 2015. Increased food energy supply as a major driver of the obesity epidemic: a global analysis. *Bulletin of the World Health Organization* 93: 446-456. <http://dx.doi.org/10.2471/BLT.14.150565>
- Varagiannis, P., Magriplis, E., Risvas, G., Vamvouka, K., Nisianaki, A., Papageorgiou, A. and Zampelas, A. 2021. Effects of three different family-based interventions in overweight and obese children: The "4 your family" randomized controlled trial. *Nutrients* 13(2): 1-12. <https://doi.org/10.3390/nu13020341>
- Williams, J., Scarborough, P., Matthews, A., Cowburn, G., Foster, C., Roberts, N. and Rayner, M. 2014. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. *Obesity Reviews* 15(5): 359-374. <https://doi.org/10.1111/obr.12142>
- World Bank. 2017. *An overview of links between obesity and food systems: Implications for the food and agriculture global practice agenda*. Washington, D.C.: World Bank. <https://documents1.worldbank.org/curated/en/222101499437276873/pdf/117200-REVISED-WP-Obesity-Overview-Web-PUBLIC-002.pdf>
- World Bank. 2020. Cause of death, by non-communicable diseases (% of total). <https://data.worldbank.org/indicator/SH.DTH.NCOM.ZS>
- WHO. n.d. Malnutrition in all its forms. <https://www.emro.who.int/nutrition/double-burden-of-nutrition/index.html>
- WHO. 2007. *National Food & Nutrition Policy & Strategy 2007-2017 Egypt*. World Health Organization Global database on the Implementation of Nutrition Action (GINA). <https://extranet.who.int/nutrition/gina/en/node/17826>
- WHO. 2017. Body Mass Index (BMI). World Health Organization Global Health Observatory. <https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index>

- WHO. 2019. *Global status report on alcohol and health 2018*. Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789241565639>
- WHO. 2020. Physical activity. Fact sheet. World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/physical-activity>
- WHO. 2021a. Noncommunicable diseases. Fact sheet. World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases>
- WHO. 2021b. Obesity and overweight. Fact sheet. World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- Yang, Z. and Huffman, S.L. 2013. Nutrition in pregnancy and early childhood and associations with obesity in developing countries. *Maternal & Child Nutrition* 9: 105-119. <https://doi.org/10.1111/mcn.12010>
- ZSA, MoH, UTH-VL and ICF. 2020. *Zambia Demographic and Health Survey 2018*. Lusaka: Zambia Statistics Agency, Ministry of Health, University Teaching Hospital Virology Laboratory, and ICF. <https://www.dhsprogram.com/pubs/pdf/FR361/FR361.pdf>



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