

School food systems

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Key points

- Reorienting food systems for children and adolescents is central to improve children's healthy and sustainable diets.
- Interventions on food systems for children and adolescents focusing on schools offer promising venues for improving children's diets and health with a special focus on most vulnerable children and adolescents.
- School settings offer relevant opportunities for interventions that range from food subsidies and taxes, the provision of daily healthy and sustainable meals and the improvement of school food environments.
- School Food Systems changes should include a policy equity perspective to protect childhood optimal nutrition as a fundamental human right ensuring at least one healthy and sustainable meal per day.

Introduction

An adequate nutrition in early childhood, the school-age years, and adolescence is a fundamental piece for physical growth, learning process and adult healthy life. Healthy children and adolescents (C&A) in our societies are the basis of a prosperous world. The current child and adolescent health situation around the world is far from the ideal levels of health achievement. Undernutrition—stunting and wasting—is still prevalent in young children, at the same time that overweight and obesity among children and adolescents continues rising or stagnated at high prevalence in most parts of the world including regions where undernutrition is still prevalent ([Aguayo and Morris, 2020](#)).

An important, and often neglected, matter when studying population health is the social gradient of health and nutrition that characterizes our current populations. Malnutrition, in the forms of overweight and obesity disproportionately occurs in under-served and vulnerable communities within our populations. And these health and nutrition inequalities continue rising in most countries, including high income countries like the US and European countries. Food insecurity continues increasing in countries like the US and Spain, a situation that worsened during the COVID-19 pandemic. A relevant topic when addressing children health and nutrition is the high cost of healthy diets in comparison to cheap energy-dense, nutrient-poor foods. The recognition of health and nutrition as a human right specially for C&A needs to be moved forward in most countries' political agenda. The need for including health and nutrition as part of Child Guarantee schemes in our countries is an ongoing political debate in Europe.

In the last decades, it has become clearer that food production significantly contributes to the challenge of sustainability by contributing to biodiversity loss, climate change, freshwater usage, food loss and waste and long-distance transportation, for example. Individuals and families contribute to these problems through their daily food choices (Oostindjer et al., 2017).

A food systems approach has been developed in the last decades for addressing and understanding the complexity of all the factors that finally affect the dietary patterns we follow and the related nutritional and health outcomes in different societies. The most common definition of a food system is as follows: “a food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socio-economic and environmental outcomes” (HLPE, 2017).

Food systems thinking should also help ensuring that food is produced, distributed and consumed in a sustainable manner protecting the right to adequate food for present and future generations (HLPE, 2017). The way modern food systems are thought, helps policy-makers focusing on the availability and accessibility of diverse and healthy diets, particularly for the underserved and the most vulnerable.

Food systems for children and adolescents

A food systems approach promoting C&A’s adequate health and nutrition while minimizing environmental degradation is warranted. Food systems research had seldom considered children and adolescents as a focus until UNICEF and the Global Alliance for Improved Nutrition (GAIN) convened a Global Consultation on Food Systems for Children and Adolescents at the UNICEF Office of Research, Innocenti, from 5 to 7 November 2018. The results of this meeting have been published in a special issue on Food Systems for Children and Adolescents addressing the need for food system reorientation with a child-centered approach (Aguayo and Morris, 2020).

Food systems comprise actors, components, policies and services that influence and interact with each other in a complex ecology where the whole system needs to be synchronized to ensure nutritious, safe, affordable and sustainable children diets.

Actors lie both in public and private sector. Food systems require from all food system stakeholders the most difficult task of responsibly assuming their roles in shaping children diets.

Governments have the higher responsibility for upholding children rights to adequate nutrition and health and must set food standards aligned with the special needs of C&A. Producers and suppliers must ensure that their actions are aligned with those standards. Finally, governments shall generate the conditions to allow for participation of small-scale stakeholders, families, women and vulnerable groups among other players.

Raza et al. (2020) developed the Innocenti conceptual framework of food systems for C&A that shape their diets comprising four types of diet determinants: food supply chain, food environment, both personal and external, and children/household eating behaviors.

Within each determinant Raza et al. identified a series of “influencers” that are more immediate and individual/level factors determining the extent to which a determinant contributes or not to the goal of improving C&A diets becoming potential entry points for food system change.

Determinants of food systems for children and adolescents

Food supply chains

Food supply chains take food from production to consumption. Small and medium scale farms produce 50% of world food. They face challenges diversifying their production due to inputs cost. Public sector shall support them in aligning their practices with C&A dietary needs given the investments needed in practices and foods of current limited demand in the market.

Government can secure markets for these foods and sustainable food practices fostering partnerships with schools (farm-to-school twinning) and designing sustainable public food procurements strategies that truly value C&A nutritional health, community social justice and environmental integrity, the three pillars of sustainable development (Dos Santos et al., 2022).

Food environments

External food environments

The school is a salient food environment for C&A as it allows reaching them at population level at least until mid-adolescence. C&A spend more time in school than in any other environment.

Food systems may differ by country even by state or region. For example, in the US around 30 million C&A participating in the National School Food Programs (lunch and breakfast) in public schools may consume up to half of their daily calories at school (Cohen et al., 2021), which underlines the importance for these calories being healthy ones.

Because of the time spent by C&A at school at a time in their lives where food habits are established and therefore might track into adulthood, the school setting provides multiple opportunities to learn healthy but also sustainable food behaviors, while mutually reinforcing each other.

School meals in any given country are a nutrition and health safety net for low-income and vulnerable children (HLPE, 2017). The availability and accessibility of water coolers and water fountains has received plenty of attention in the last years given the current situation of sugar sweetened consumption and plastic bottles and containers increased use.

Personal food environments

Accessibility to healthy food options around schools and the place of residence remains an important factor within food systems thinking.

The affordability of healthy dietary patterns is a major economic problem for many families as shown in the high levels of food insecurity. Social protection schemes at schools providing healthy and free meals to low-income families and those in need is, again of most relevance.

Convenience foods offered in school and high-school breaks are mostly cheap and ready-to-eat foods, high in sugar, salt and calories compromising optimal diets.

Behaviors of caregivers, children and adolescents

The Innocenti framework visualizes this final determinant where the external food environment i.e. school and personal food environments converge. Desirability and acceptability of food options are linked to social and cultural norms but can be heavily influenced by marketing and advertising (Fox and Timmer, 2020).

This framework conceptualized the dynamic linkages between the elements of food systems and highlighted the importance of continuously shaping food systems to deliver nutritious, safe, affordable, and sustainable diets to children and adolescents.

School food systems

What children eat depends on the food system environments in the communities where they live and where they attend school. School settings have been identified for decades as places for change in public health nutrition.

The school food system is a subsystem within the broader food system of particular relevance for C&A. It also a food environment i.e. a physical and socio-cultural context whereby C&A interact with the broader food system to obtain the food they need most commonly as lunch but also as breakfast and/or snacking.

Because of the time dedicated to eating at schools, and the influence of school social environment (teachers and peers) on C&A food choices, schools are in a unique situation to influence the behavior of many children simultaneously cutting across socio economic status.

Healthy food habits are more easily acquired in childhood, and early learning increases the chances of habits persisting into adulthood. School meal programs are therefore a tool for improving dietary behaviors, nutritional outcomes in a sustainable way (Oostindjer et al., 2017).

Education and health policies also have the possibility to serve as examples and levers of change in other sectors of society where scaling up healthy and sustainable food production and consumption is also needed (e.g. hospitals, nursing homes, universities). School Food System approaches should acknowledge their transformative power and ability to drive change.

The SchoolFood4Change project (Website <https://schoolfood4change.eu>) funded by the EU scheme Horizon 2020 tackles the transformative power and ability to drive change of schools by bringing food and nutrition to the heart of the school mission reinforcing the health and sustainability parts of food consumption.

Researchers involved in the project used the following school food systems definition further explained in Fig. 1 for school food systems promoting healthy and sustainable school diets.

School food systems include the full range of **activities, components**, and actors related to the production, processing, distribution, cooking, serving, consumption, and waste management of food in schools, as well as the **spaces and contexts** where these processes occur, and all the related educational practices, that promote children and adolescents' health in a way that is profitable for each actor of the food value chain, respects the social and cultural context, and safeguard, restore, and regenerate natural resources and ecological processes while respecting planetary boundaries. School food systems shall be governed democratically in a participatory way by all its **actors**, including farmers, procurers, chefs, teachers, pupils, parents, administrative municipal and school staff, researchers, other professionals, and policymakers.

Following a systemic approach, the school food system is a collection of subsystems with components, spaces, actors interacting in different processes through feedback loops. This is a fundamental characteristic of systems thinking that in the case of School Food Systems should help us focusing on the goals of promoting healthy and sustainable school diets for all the children attending with a focus on those most vulnerable.

School food systems and food programs

Within the school food system, the school food environment greatly interacts with C&A influencing their food choice since they spend a considerable part of their day at school where they have at least one meal (Cohen et al., 2021).

School food programs (SFPs) are frequently nationally mandated initiatives, sometimes regional and even municipal, to promote healthy and sustainable food behavior in C&A attending the different schools. Their interest lies on the fact that can reach school-aged C&A at population level across socioeconomic classes, particularly when school food programs are free, in a children development stage when food habits are formed and might therefore track into adulthood (Oostindjer et al., 2017).

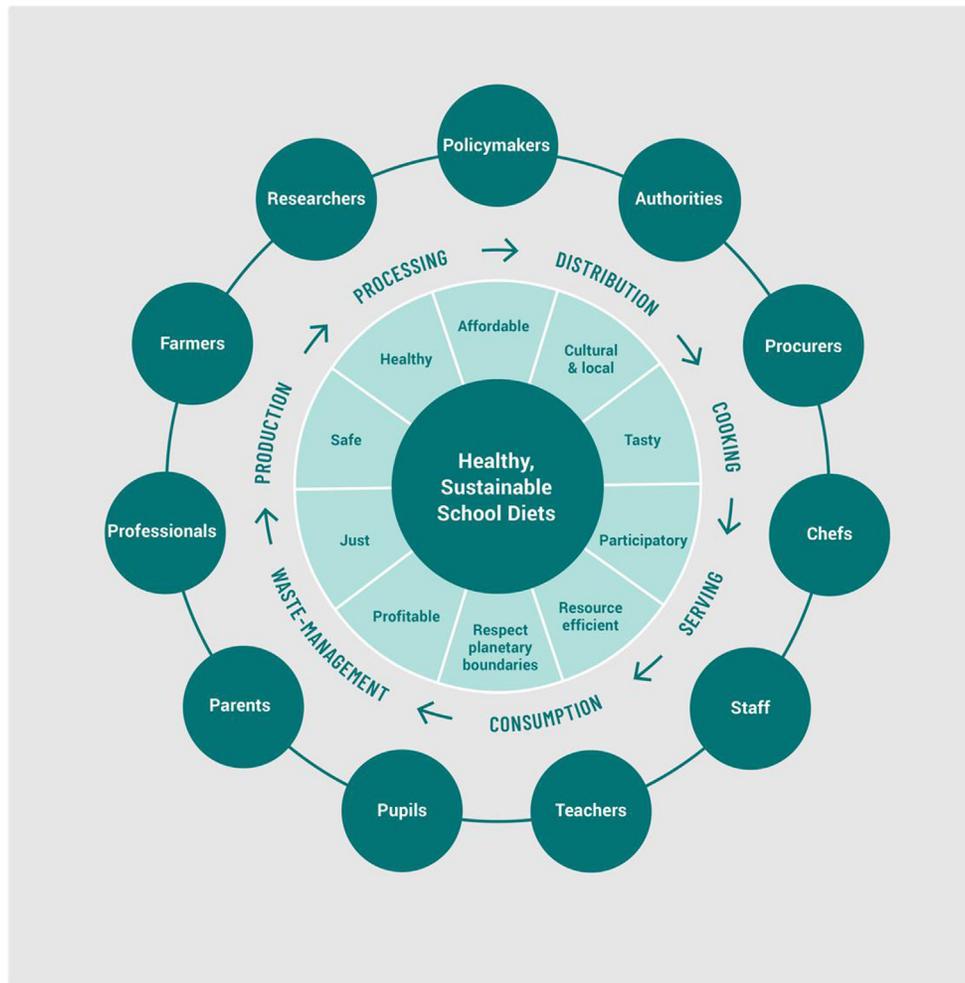


Fig. 1 Components of school food systems promoting healthy and sustainable school diets. This conceptual framework figure was proposed within the school food four change project. <https://schoolfood4change.eu>.

These programs provide lunch, but also breakfast or just one commodity such as school fruit or milk programs. In the USA, 95% of non-profit schools participate in the school meal programs administered by the United States Department of Agriculture (USDA). Both the National School Lunch Program (NSLP) and the School Breakfast Program (SBP) provide children and adolescents with healthy, low-cost meals throughout the school year. Additionally, before the COVID-19 pandemic, approximately three-quarters of the NSLP participants came from low-income households, with many relying on school meals for up to half of their daily energy intake (Cohen et al., 2021).

Schools are therefore in a unique situation to promote healthy and sustainable eating among C & A while at the same time, reducing disparities in the consumption of healthy foods such as vegetables and fruits (Longacre et al., 2014).

Historical development of school food programs (1850-present)

Oostindjer et al. (2017) have suggested three phases in the progression of nationally mandated SFPs in high-income countries. Those phases are described in Fig. 2.

In phase I (1850–1970) SFPs were introduced as a response to hunger and as such they were considered welfare programs aiming at providing sufficient food energy to low socioeconomic status children.

During phase II there was a shift toward food quality around 1970s in some European countries and in 1990s and 2000s in the USA and the UK as a response to increased prevalence of diet-related diseases resulting from increased food availability. Many developed countries, including USA and most European countries, issued national dietary guidelines focusing in reducing energy levels while increasing the number of nutrients per kilocalorie. This phase still continues as of today in many countries.

Phase III emerges since phase II seems unable to respond to individual (providing high-quality food to reduce all forms of malnutrition) and societal (preserving the environment to do the same for future generations) challenges in a sustainable food context. This phase is in its infancy in many countries coexisting with phase II. It aims at transforming SFPs in integrative learning

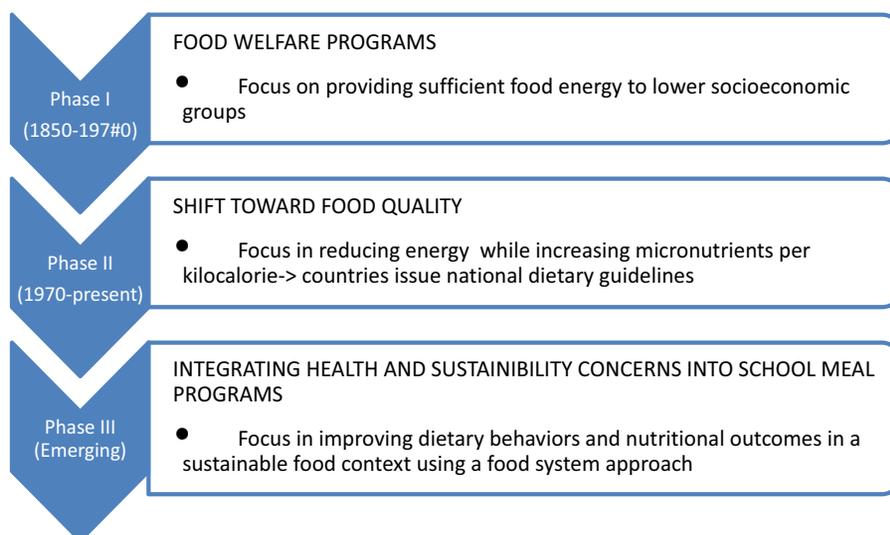


Fig. 2 Progression of school meal programs in the world after Oostindjer et al. (2017).

platforms for healthy and sustainable food behaviors at school using a food systems approach. This systemic approach requires synchronized changes across the food system components, given the interdependencies in the process of bringing food from farm to school fork and from there to school food waste (Hernandez et al., 2018). These concepts are being discussed and developed as of 2022 and therefore have not extensively studied yet.

The example of the Brazilian national SFP

The Brazilian SFP (PNAE in Portuguese) is a long standing national SFP that currently and after 2009 modified legislation, is world-wide recognized as a healthy diet promoting initiative (Boklis-Berer et al., 2021) offering Brazilian C&A attending public schools, free meals where products rich in Na, sugar and saturated and trans fats are restricted and the provision of low nutrition drinks prohibited including in the menus at least three portions of fruits and vegetables weekly 30% of their funds have to invested in local farm products provision and hence contributing to local development and food security of the community (Horta et al., 2019).

Regular consumption of PNAE provided meals at Brazilian schools has been associated with improvements in children diets by increasing consumption of healthy foods (pulses, vegetables and fruits) and decreasing unhealthy ones (salty snacks, crackers, sweet biscuits and sweets) further reaching those on higher social vulnerability risk (Horta et al., 2019). Additionally, the adherence to PNAE meals in adolescents (11–19 years) was associated with decreased obesity indicators (BMI, BMI z-score) showing a dose-response relationship (Boklis-Berer et al., 2021).

School food systems interventions

Downs and Demler (2020) identified in a scoping review the most effective interventions in the school food systems to improve diets and reduce the risk of malnutrition for C&A.

The school interventions showing most promising results were as follows:

- Food/snack/beverages subsidies and taxes in schools
- Provision of free or subsidized fruit and vegetables
- Provision of free school meals
- Increased water access in schools
- Setting up school meal and competitive food & beverages standards
- Salad bar in cafeterias
- Menu labeling in schools
- School food environment changes
- Portion size changes
- Social marketing of healthier foods and beverages
- Cafeteria nudges and choice architecture

Storcksdieck Genannt Bonsmann et al. on their 2014 report of European school food interventions and policies, offer a number of suggestions to increase their acceptance and hence increasing their chances of success:

- Co-involvement of head teachers: Buy-in from them
- Building partnership at different levels
- Ensuring family and local engagement
- Local ownership and co-creation (engage children, teachers, canteen staff): use bottom-up approaches, social marketing, involve C&A in design and assessment
- Capacity building (teachers, coordinators, chefs, canteen staff, caterers): provision of materials made available through a centralized good practices portal or knowledge hub.
- Synchronized multi-component interventions

School food systems interventions are aimed to have impact at different aspects of C&A health. Next, we discuss the already studied and published intervention impacts on dietary behaviors, anthropometric and metabolic outcomes. We also include a discussion on why impacts school food systems interventions have been rather unsuccessful to show positive impact on C&A health outcomes.

School food interventions and impact on dietary behaviors

Downs and Demler (2020) indicate that the choice of food in C&A can be shaped by economic incentives i.e. subsidizing healthy foods such as fruits and vegetables and taxing unhealthy ones (energy dense snacks and/or beverages). The free provision in school of fruits and vegetables (F&V) has been more successful in increasing just fruit consumption in-school and habitual intake in the short term and to some extent in the long one (Micha et al., 2018). Provision of free school meals have brought up positive changes in dietary intakes such as in the case of the Brazilian SFP (Horta et al., 2019). School meal standards have increased intake of F&V reducing fat, saturated fat and Na with no effect on calories while competitive food/beverages standards has decreased reduced sugar-sweetened beverage intake and unhealthy snacks with no effect on total sugars. Improved access to water coolers in school has shown a non-significant trend to increased water consumptions (Micha et al., 2018). Salad bars, menu labeling and social marketing campaigns showed small increases in fruit and vegetables consumption and a reduction on energy and total and saturated fat intakes. Gender based differences were detected in the use of salad bars (Down and Demler, 2020). Approaches to cafeteria nudges and choice architecture that led to improvements in favorable foods included photographs of F&V in lunch trays, strategic placement of these foods in the lunch line, etc. Further description of the effect of these interventions on health outcomes can be consulted on Down and Demler article (2020).

School food interventions and impact on anthropometrics and metabolic outcomes

The formerly mentioned school food interventions were more likely to bring up changes in dietary intake, that in other more distal health outcomes such as anthropometrics.

The effect of school food interventions on anthropometrics (body mass index (BMI), weight status) has been variable and inconsistent in European countries as reported by Storcksdieck Genannt Bonsmann et al. (2014). Likewise, in LMICs, there is also limited evidence to support the modification of anthropometric outcomes through school-based food environment interventions such as eliminating unhealthy foods (absence snack bars/vending machines) and promoting school staff modeling C&A (Carducci et al., 2020). Boklis-Berer et al. (2021) have recently reported a positive effect on adolescents' rates of obesity in the Brazilian SFP.

Concerning metabolic risks indicators such as abdominal obesity, a recent systematic review on C&A by Leis et al. (2019) supports the role of nutritional education decreasing central obesity although effects on the remaining markers of metabolic syndrome were inconclusive. Changes in the availability of competitive foods and beverages in schools i.e. sugar sweetened beverages and unhealthy snacks have shown effect decreasing C&A metabolic risk (Downs and Demler, 2020).

Barriers evaluating school food interventions impact on health outcomes

In all, there is little evidence both from HICs and LMICs countries as to whether school food and school food policies can effectively improve C&A health status and/or eating habits. The barrier to gather this evidence relies on the difficulty in implementing comprehensive and well-designed studies, inferring causal effect from observational studies and the paucity of school food interventions sustained over a significant amount of time (enough duration) with sufficient intensity (multicomponent interventions required) and adequate and continued funding (Colley et al., 2019; Storcksdieck Genannt Bonsmann et al., 2014).

Lack of clear definition of measurable health outcomes (endpoints) has also hampered school food interventions evaluation and comparability. Proximal indicators i.e. short-term outcomes have been suggested to evaluate school food environment interventions such as the increase in favorable food intakes (F&V, pulses) or the increase in number of children of low income families participating in school meals (Oostindjer et al., 2017) as well as process indicators (implementation fidelity, C&A/teachers/canteen staff satisfaction, etc). However it is unclear how these short-term health outcomes relate to long-term outcomes such as overweight/obesity and type 2 diabetes (Oostindjer et al., 2017). Using indicators revealing additional forms of malnutrition have also being suggested to show school food interventions impact on C&A health e.g. vitamin deficiency, muscle mass loss, anemia in adolescent girls or metabolic risk (central adiposity).

School food interventions and sustainability

Food production, processing, distribution, consumption and waste management are associated with significant environmental impacts. Schools are not only an adequate context to bring up positive dietary and nutritional outcomes in C&A, they are also prominent environments for sustainability practices i.e. providing C&A with a sustainable food offer as well as building citizen conscience on sustainability issues integrating education for sustainability in the school curricula (Dos Santos et al., 2022).

Focusing school food interventions on the provision of healthy but also sustainable foods along with the promotion of sustainable food behaviors through school gardening and learning how to reduce food waste, might work in a mutually reinforcing way and in doing so, spilling into life away from school (family, community) (Colley et al., 2019). Schools sustainability practices might therefore impact the environmental pillar of sustainability but also the economic and social ones.

Dos Santos et al. in a recent systematic review (2022) identified the most frequently adopted food sustainability policies and interventions worldwide as follows:

- Educational activities for sustainability:
 - School gardens providing experiential learning i.e. hands-on experience on growing vegetables and workshops on using and cooking garden produce, travel field studies, etc.
- Food services:
 - Food supply/provision->sustainable food procurement including, beyond price: environmental criteria in the food supply contracts i.e. local or short chain, seasonal and organic foods, socioeconomic criteria i.e. farm to school or fish to school programs, provision from small producers, prioritizing supply from women and other vulnerable groups.
 - Menu planning: mainly plant-based, reduced meat supply, one day vegetarian/vegan menus, exposure of children to unfamiliar/unappreciated foods)
 - Menu production/consumption/distribution:
 - Reducing energy and water consumption in meal cooking, reduce organic waste (age-range adjustment of portion sizes, single dish menu)
 - Reduce inorganic waste->reusable devices, purchase in bulk or minimizing packaging, use of returnable bottles, and replacement of bottled mineral water by filtered water
 - Recycling/Composting
 - Food donation: serving people in vulnerable situations with relatively low investment

In 2021, the Food and Agriculture Organization (FAO) highlighted the importance of schools sustainable food procurement embedded in a wider public food procurement (PFP) strategy as a key lever for food systems transformation. In their report describe how PFP can influence both, food consumption and food production patterns and how it can be used as a development tool in the framework of school meals programs delivering multiple social, economic, and environmental benefits as well as health and cultural ones.

The EU funded SchoolFood4Change project (<https://schoolfood4change.eu>) is an example of innovative use of sustainable school food procurement to ensure healthy and sustainable food to C&A, particularly those more deprived.

Next steps and opportunities

In order to keep on developing School Food Systems knowledge and interventions that can have the highest impacts on C&A health and sustainability there are several topics where more and better knowledge is needed.

- As suggested by Oostindjer et al. (2017), being at the forefront of the shift toward phase three of school food programs will require a curricular integration of school meals with a focus on disease prevention and sustainability, as well as including current societal concerns such as climate change, environmental degradation, social justice and equity.
- A policy equity perspective is of paramount relevance given the highly unequal societies we live in nowadays with a well-known social gradient of C&A malnutrition. Protecting children health and nutrition as a fundamental human right and providing at least one healthy and sustainable meal per day in every school is a current challenge and opportunity.
- Harmonizing school food programs indicators for C&A dietary behavior and nutritional health and food sustainability will allow for evaluation and comparability and it is still the next step in knowledge and innovation application in schools worldwide.

As suggested by Hawkes et al. (2020), reorienting food systems toward healthier diet for C&A in any context is one relevant next step. Hawkes et al. recently developed a 6-step tool to identify actions toward child-centered food systems making healthy diets AAAA i.e. available, affordable, appealing, and aspirational in the context of children lives. The tool starts with the context in which children live or in our case, the school they attend and works back upstream;

1. Collecting data on nutritional health burden at the school level->malnutrition target e.g. overweight/obesity
2. Perform dietary assessment to identify both the eat more and eat less foods.

3. Use qualitative methods to understand the C&A dietary behaviors context (i.e. mapping of school food provision practices and assets).
4. Children-centered food environment measures at school->targeting food environment aspects to be changed to make certain foods more or less AAAA in short- and long-term.
5. Analysis of local food supply systems: Incentives or disincentives to create healthier food environment via a school food procurement supporting food offer diversification and sustainable food production practices (e.g. organic).
6. Develop mutually complementary actions: For example, the EU SchoolFood4Change project mix of actions: (1) healthy and sustainable food procurement, (2) Planetary healthy diets and cooking, (3) Whole School Food Approach to achieve a child-friendly food culture at school.

Conclusion

The current children and adolescent's health and nutrition status worldwide should be understood from three relevant features: High and rising prevalence of overweight and obesity in most countries of the world. The existence of a clear social gradient of health and nutrition in children and adolescents worldwide. The food system needs to take into account not only the provision and consumption of healthy foods, but the sustainability of all processes of food production and distribution to protect biodiversity and reduce its impact on climate change.

The study of school food systems offers different intervention opportunities to improve the health and nutrition status of children and adolescents, especially for the most vulnerable. School food systems interventions should also promote more sustainable diets.

Several conclusions emerge from this work on school food systems. First, interventions should include a wide range of intersectoral policies and actions comprehensively implemented in concert to achieve highest impact. Second, education and health policies need to be advocate for the relevant issue of healthy food affordability. Finally, engagement and accountability of both public and private sectors are needed.

School settings offer a clear opportunity for sustainable, healthy and equitable food system change including the development of innovative and sustainable food procurement criteria, the promotion of planetary healthy diets and cooking, and the use of a whole school food approach for schools to become integrative learning platforms.

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Relevant websites

- Global Research Consortium for School Health and Nutrition. <https://www.lshtm.ac.uk/research/centres-projects-groups/research-consortium-for-school-health-and-nutrition>.
- School Food for Change EU project. <https://schoolfood4change.eu>.
- The EU School Fruit, Vegetables and Milk Scheme From the Common Agricultural Policy, Supports the Distribution of Milk, Fruit and Vegetables to Millions of Children, From Nursery to Secondary School, Across the EU. https://agriculture.ec.europa.eu/common-agricultural-policy/market-measures/school-fruit-vegetables-and-milk-scheme_en.
- The Global Alliance for Improved Nutrition (GAIN). <https://www.gainhealth.org/about>.
- The School Meals Coalition, an Initiative Led by a Group of Member States and Partners to Ensure That Every Child has the Opportunity to Receive a Healthy, Nutritious Meal in School by 2030. <https://schoolmealscoalition.org>.