Towards Food System Innovations

Characterizing Food System Components and Evaluating Pilots in Viet Nam

Mai Trang Nguyen

Propositions

1. Framing the scope of assessment is key to rigorous impact evaluation of a food system intervention.

   (this thesis)

2. A healthy food environment goes beyond health, food and environment.

   (this thesis)

3. Limited data in low- and middle-income countries propels scientific progress through the urge for innovation.

4. The current peer-review process is more about recognition than science communication.

5. To fight against threats to public health, scientists must take on the role of social media influencers.

6. Achieving sustainability is all about solving tensions.

7. Misunderstanding freedom is as dangerous as the lack of freedom.

Propositions belonging to the thesis, entitled

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Towards Food System Innovations

Characterizing Food System Components and Evaluating Pilots in Viet Nam

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Characterizing Food System Components and Evaluating Pilots in Viet Nam

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To my families.

Contents

Chapter 1	Introduction	1
Chapter 2	Determining Priority Research to Improve Food Systems	11
Chapter 3	Interactions between Food Environment and Consumption	41
Chapter 4	Evaluating Methods to Increase Consumption of Healthy Foods	85
Chapter 5	Nudging towards Healthier Food Choice for Children	159
Chapter 6	General Discussion	195
References		207
English Summary		225
Acknowledgements		227

CHAPTER 1

Introduction

1.1. Problem Statement

Malnutrition in all its forms incurs immense costs to nations. The human impacts of malnutrition, such as mortality, poor health, poor physical growth and impaired cognitive development, translate into huge economic impacts at individual, societal and national levels (Beddington & Kufuor, 2016). It was estimated that the global annual cost of malnutrition, which covers lost productivity and direct health care costs, could be as high as US$500 per individual (Food and Agriculture Organization of the United Nations, 2013). While one in every nine people are still suffering from hunger, overweight and obesity are rapidly increasing in all age groups and across all regions (FAO et al., 2019). For low and middle-income countries (LMICs), the double burden of malnutrition (DBM), due to both deficit and excess, impose particular grave consequences (World Food Programme, 2017; Popkin et al., 2020). According to the most recent surveys, of the 126 LMICs with data from the 2010s, the number of countries facing the DBM was 48 (38%) (Popkin et al., 2020). The risk the DBM is starting to concentrate among vulnerable populations - people with low incomes and in rural areas. The rise of overnutrition is accompanying the transition from a traditional to a modern diet, driven by urbanization, globalization and economic growth (Popkin et al., 2012; HLPE, 2017).

As causes of malnutrition are complex and multidimensional, addressing the burdens of malnutrition requires an integrated approach across sectors and disciplines. One such approach that has gained prominence as a central entry point for action in nutrition and food security is through food systems (Béné et al., 2019). Using a systems perspective, the interactions between different parts of a system can be considered to understand how they affect change together rather than through isolated components (Oxfam, 2014). A food system can be defined as “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 outputs of these activities, including socio-economic and environmental outcomes.” (HLPE, 2017). The framework of food systems provides the lens needed to analyze the issues related to malnutrition in different settings, in

order to identify the necessary leverages for intervention, either across the supply chain, within food environments, or related to consumer behavior and food system drivers (HLPE, 2017). The magnitude of the issues, sectors and disciplines involved in this framework requires a targeted and prioritized approach for a specific context (HLPE, 2017). Therefore, this study started by identifying priority research questions at a national scale, through a comprehensive review of the evidence base on the components of the national food system in focus. Based on the results of this exercise, one of the priority research questions was selected to be the starting point. This gave rise for evaluation studies on 2 pilot school-based interventions on school food environment and food choice behavior. Besides the school environment scale, the thesis also dissects the food environment at a community scale. Accounting for the multiple scales of the food environment is crucial to understand the impacts of interventions on diets, nutrition status, and health outcomes in LMICs (Turner et al 2018).

This thesis uses Vietnam as the local food system in focus. As one of those 48 LMICs with DBM, the country demonstrates the story of how the nutrition transition has been taking place. The liberating economic reforms in 1990s lifted the country out of the status as one of the poorest nations. This was followed by the decline in consumption of mainly starchy staples and increases in protein-rich consumption, which helped to lower the prevalence of undernutrition (Le Nguyen et al., 2013). Concurrently, unhealthy food consumption patterns started to show: such as high consumption of salt, ultra-processed foods (including instant noodles) and sweetened non-alcoholic beverages, as well as lower consumption of fresh fruit, vegetables and seafood (Nguyen & Hoang, 2018). Among 18–65 years old Vietnamese, the prevalence of overweight and obesity increased from 2.3% in 1993 to 15% in 2015 (Nguyen & Hoang, 2018). This thesis provides insights on how food system research can be leveraged to inform innovations that support the country with its developmental goals, such as in fulfilling Viet Nam National Nutrition Strategy until 2030. Research findings from the Vietnamese context would offer opportunities to draw lessons and implications for other settings, especially countries with similar concerns and going through the nutrition transition.

Figure 1 shows how different studies in the thesis are tied to the food system framework for healthier diets.

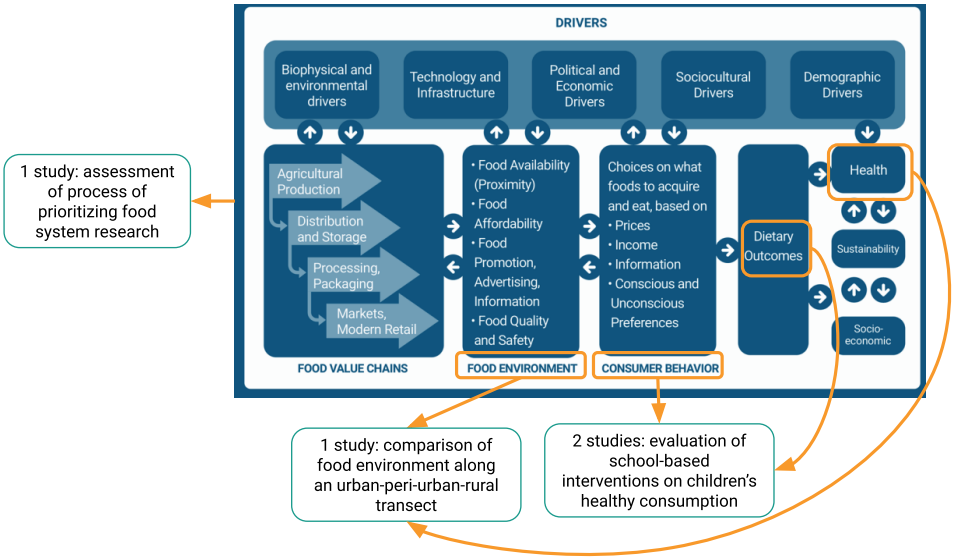

Figure 1. *Food system framework (de Brauw et al., 2019: Fig 2, adapted from HLPE (2017)) and this thesis*

1.2. Objectives and Research Questions

As the title suggests, this thesis revolves around two key objectives: to characterize the food system components for healthier diets, and to evaluate some pilots of food system innovations towards the next course of action. This thesis addresses the following research questions:

1. How can research priorities be defined for a local food system, considering practices from related domains such as health and nutrition?
   (Chapter 2)
2. How do food environment characteristics vary across a local transect? How are their relationships with consumption and nutrition outcomes?
   (Chapter 3)
3. What are the potential impacts of interventions to improve children's consumption in a food environment setting?
   (Chapter 4 & 5)

1.3. Literature

Priority setting for food system research

In alignment with global priorities for food system research (FAO, 2017b; HLPE, 2017), setting priorities at a local level is a crucial yet daunting task. Setting research priorities is a formal procedure to generate consensus between different stakeholders on research questions considered a priority for resources allocation. As each local food system is faced with unique challenges and resource constraints, a rational and transparent formulation of research priority questions and the development of research agendas can help optimize the allocation of limited resources. Nevertheless, the paucity of detail about the priority setting process and the lack of transparency was common across many LMICs (Tomlinson et al., 2011).

Although priority-setting exercises have been common in nutrition and health, such a process for food system research has been rare. Recent examples include the works by De Brauw et al. (2019), Raneri et al. (2019) and Gebru et al. (2018). Nevertheless, these working papers stopped after formulating a list of research questions. There is also a call to address the research waste by not only focusing on the research priority setting, but also to provide follow-up and evaluation of such an initiative (Chalmers et al., 2014).

In Chapter 2, besides critically reviewing the priority setting process in reflection of established approaches in other domains, we reported and assessed some initial outputs from the research agenda, discussed the lessons learned and the implications of the priority-setting process for local food systems.

Food environment in LMICs

Food environment research has gained momentum in recent years within high-income countries (HICs) in response to the high prevalence of overweight, obesity, and non-communicable diseases (NCDs) (Caspi et al., 2012; Gamba et al., 2015; Lytle & Sokol, 2017). Although the number of publications on LMIC's food environment is increasing, they predominantly feature upper-middle-income countries and outcomes related to overweight and obesity. The limited number of studies on food environment in LMICs poses a problem because issues of concern in developing countries may be very different from those of developed countries (Turner et al., 2019). For example, non-market food sources (e.g. own production and food transfers) and dominance of the informal retail sector are typical of LMICs,

and undernutrition remains prevalent. Turner et al. (2018) covers these elements in their food environment framework. In spite of the available framework, studies have been constrained by the limited existence of data, for example geo-coded datasets that cover the outlet diversity in many LMICs (Turner et al, 2018). The number of published studies on food environment that went beyond one setting in a national context is limited, as these studies require rich transect data.

In chapter 3, with extended typologies, our study attempts to cover smaller vendors to reflect the availability dimension of the local food environment. By looking at the food environment across an urban – peri-urban - rural gradient (using data from three different sites in North Viet Nam) our study provides important detailed information about food environment in an emerging economy in transition. Research on the food environment can play an important role in explaining such differences and in drawing relevant recommendations, for example in identifying points of leverage for interventions and innovations.

Food system innovations and school-based intervention

A potential use of food system research in improving diets is through a food system innovation, defined as "a policy or regulation, an institutional process, a change in knowledge, a technology, or combination thereof that is either not used or not widely used within a food system, but has the potential to change diets on a wider scale" (De Brauw, Van Den Berg, et al., 2019). Interventions are a subset of innovations that take place largely through public investment rather than by the private sector alone, or through public-private partnerships. Many LMIC have included school-based interventions in their nutrition policies to combat the burdens of unhealthy diets. Recent systematic reviews of policy actions to improve diets in LMIC indicated that school-based activities are present in several different regions (Lachat et al., 2013; Darfour-Oduro et al., 2019). Schools are an attractive entry point to improve children's diets, as their eating habits can be shaped during childhood and the information disseminated from school can reach adults through children (Jomaa et al., 2011; He et al., 2015; Loewenstein et al., 2016; Gunawardena et al., 2016; DeCosta et al., 2017). Nutrition education programs can positively influence the knowledge and attitude of children regarding healthy foods (Katz et al., 2011; Prelip et al., 2012; Lerner-Geva et al., 2015), while exposure and access to healthy food can induce demand and increase intake of healthier foods due to the strong relationship between familiarity and preferences (Cooke, 2007a; DeCosta et al., 2017).

Providing children with free and accessible FAV has been found to positively influence children's eating behavior, even in the long term (DeCosta et al., 2017). Nutrition education alone does not always lead to behavioral changes (Katz et al., 2011; Prelip et al., 2012; Mittmann et al., 2016) and can be more effectively improved if a nutrition education curriculum and parental involvement are combined with FAV availability in schools (Van Cauwenberghe et al., 2010; Sharma et al., 2016). In practice, it is useful to evaluate how the two approaches complement each other to advise practitioners on whether to pursue a holistic program in the face of constraints.

There is a paucity of rigorous evaluations of school-based interventions related to healthier eating in LMICs, where evidence has been limited to pre-post comparisons (Lagerkvist et al., 2018), or randomized control trials with a small sample size (He et al., 2015). While a large body of research studying interventions to reduce undernutrition in developing countries exists, when it comes to promoting healthier food options, such as FAV consumption, existing systematic reviews show a bias for evidence in developed countries (Evans et al., 2012).
Although school-based interventions can potentially disseminate their messages beyond the school environment and have systematic impacts, the body of literature examining this type of spillover is relatively small. No conclusive evidence has been found on whether at-school interventions for children lead to dietary changes at home (Taylor et al., 2013).

In Chapter 4, we implemented a cluster-randomized trial in 12 schools in peri-urban Viet Nam to assess if two school-based interventions, one targeting nutrition education and the other targeting availability of healthy foods, increased knowledge of healthy diets among children and their parents, as well as children's consumption of healthy foods.

Behavioral interventions to improve children's food choice

Behavioral economists have introduced nudges as a potentially powerful and increasingly trusted public policy tool to improve people's behavior, including eating more healthily (Thaler & Sunstein, 2008; Bauer & Reisch, 2019; Sunstein et al., 2019). Examples include activating health goals at the moment when decisions are being made (Wilson et al., 2016), and social-norm based health messages about others' behavior (Robinson, 2013). Among younger consumers, incentives such as competition (Belot et al. (2016) have been a popular medium to steer children towards healthier choices.

While multiple behavioral science concepts have been tested and successfully scaled up, there exists a lack of research that tries to use cognitive dissonance to influence healthy food behaviors (Ong et al., 2017). Cognitive dissonance relates to the internal discomfort people feel when their beliefs, emotions, attitudes and actions enter into contradiction with one another (Festinger, 1957). People are then motivated to reduce this tension by adjusting their beliefs or actions. Empirical evidence has shown the effectiveness of arousing dissonance in studies related to changing behaviors towards socially desirable ends such as water use reduction (Dickerson et al., 1992), condom use (E. Aronson et al., 1991), charitable giving (Kessler & Milkman, 2018) and reducing hypothetical bias in contingent valuation studies (Alfnes et al., 2010). Among the most frequently utilized approach to arouse cognition dissonance, the induced hypocrisy paradigm was first developed by Aronson et al. (1991). They designed a sequential procedure to achieve cognitive dissonance, by illustrating the gap between what a person knows he or she should do in a certain situation (socially desired behaviors) and what he or she actually did (transgressions). A recent meta-analysis supports that hypocrisy induction has a moderate positive effect on both behavioral intention and behavior (Priolo et al., 2019).

In Chapter 5, we run the first experiment to our knowledge on children's food choice using a dissonance arousal nudge. Previous research has used the same tactic to steer children away from other harmful behavior, e.g. risky behavior on the playground (Morrongiello & Mark, 2008) or substance abuse (Ager et al., 2008). Second, we evaluate whether the dissonance arousal nudge improves the use of an information provision nudge. While providing information is a cheap and scalable approach, the evidence regarding its effectiveness in behavior change has been mixed (Bauer & Reisch, 2019). In fact, educational messages have failed to influence behavior in several studies on food choice (List & Samek, 2015; List et al., 2015). Our experiment adds a hypocrisy inducing procedure to the information-provision condition and compares it with the information only condition. In studies using a hypocrisy paradigm to motivate good behavior among younger subjects, such as those by Morrongiello and Mark (2008) and Ager et al. (2008), information was embedded in the activities. It was not clear if hypocrisy played a fundamental role or the educational aspect or the information mattered most. Our research also adds to the nascent body of experimental work on children's

food choice, especially in LMICs. The majority of publications on school-based food choice experiments have been in the developed countries, such as the United States.

1.4. Methodologies

Literature review and stakeholder engagement

For Chapter 2, to paint a holistic picture of the food system in Viet Nam, we pooled a large amount of secondary data from publications and gray literature to characterize the components of the food systems. Food systems analysis requires interdisciplinary inputs and involvement of multisector stakeholders (Ruben et al., 2018). The study involved a large number of interdisciplinary stakeholders, including non-science parties, from the stages of literature review, validation of findings, and prioritization of the research questions. Stakeholders' discussion and opinions were collected during the process.

Mixed-method research

In Chapter 3, the study used a sequential mixed methods design, as multiple tools that complement each other are required to capture the various dimensions of food environment (Herforth and Ahmed, 2015). We first obtained quantitative data, which was a combination of static geospatial data (GPS) and observational survey data. GPS data established the measures of food environment, including proximity (distance from household to food outlet) and availability (count of outlets per administrative area). We then continued with qualitative data collection, where we interviewed household shoppers about their perceptions of the food environment. The data was analyzed independently using a common conceptual framework and research questions. The analysis results were integrated and brought together in the overall interpretation.

Randomized control trial

In Chapter 4, to evaluate the effectiveness of a pilot intervention on children's nutrition knowledge and food consumption, we conducted a randomized control trial, which were pre-registered on The American Economic Association's registry for randomized controlled trials. The study's IRB were approved by IFPRI and NIN. The study involves three data collection rounds: Baseline (four weeks prior to the intervention), Endline 1 (during the last week of the intervention) and Endline 2 (six months after the intervention ended). Various types of data

were collected from food diary collection, child questionnaire, lunchtime observation, and parent questionnaire.

Lab-in-field experiment

The study in Chapter 5 made use of the set-up of the previous study to set up a lab-in-field study. This study involves the same subject as of the RCT, but only involves a 5-minute treatment. Experimental data involved children's choice out of three kinds of milk. This selection serves as behavior outcome measure for the experiment and was disguised as a thank-you gift for the children who participated in the study. The design of this study was pre-registered on egap.org Registry. The study's IRB were approved by IFPRI and the University of Public Health of Hanoi.

Experimental methods used in Chapter 4 and Chapter 5 helped to establish the causal relationship between our intervention and the intended outcomes.

1.5. Thesis Outline

Following this Introduction, the chapters in this thesis are organized as follows.

Chapter 2 discusses the process of identifying research questions to address the rising challenges of the food systems in a local LMIC setting. It sets the stage in Viet Nam, where the stories from the next chapters are unveiled.

Chapter 3 focuses on one crucial component of the food system: food environment. The study uses a dataset that cover an urban - peri-urban - rural transect to characterize and identify potential elements of the food environment that influence consumption and nutrition outcomes.

Chapter 4 shifts away from the community level food environment and look at a particular scale of food environment: school food environment. After a scoping study to identify entry points, this study tested the effectiveness of a school-based pilot intervention to encourage healthy eating among primary school children.

Chapter 5 zooms in the food consumption at a behavioral level, by implementing and testing an information treatment and a cognitive-dissonance-inducing treatment that nudge children towards healthier food choices. This study made use of the data collection implementation of the previous study and highlights the need for transparency about add-on researches.

Finally, the last chapter provides a discussion of the main findings of this thesis, reviews its limitations and offers some recommendations for future research.

CHAPTER 2

Determining Priority Research to Improve Food Systems

A participatory exercise in Vietnam

Abstract

With increased burden of malnutrition on global health, there is a need to set clear and transparent priorities for action in food systems at a global and local level. While priority settings methods are available for several adjacent domains, such as nutrition and health policies, setting priorities for food system research has not been documented and streamlined. The challenges involve food systems' multisector, multi-stakeholder and multi-outcome nature. Where data exists, it is not easy to aggregate data from across food system dimensions and stakeholders to make an informed analysis of the overall picture of the food system, as well as current and potential food system trade-offs to inform research and policy. Once research priorities are set, they risk staying on paper and never make their ways to concrete outputs and outcomes. In this paper, we documented and assessed the inclusive process of setting research priorities for a local food system, taking Vietnamese food systems as a case study. From this exercise, we examined how priority setting for food systems research could learn from and improve upon earlier priority setting research practices in other domains. We discussed the lessons for research and policies in local food systems, such as the need for a concrete follow-up plan accompanying the priority setting process.

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2.1. Introduction

Achieving a world with no poverty, zero hunger, reduced inequalities, and responsible production and consumption are all key challenges of the Sustainable Development Goals (United Nations 2015). A food systems' perspective provides an encompassing approach to consider all of these issues. While global priorities for food systems research are available (Haddad et al., 2016; HPLE, 2017), local research priority setting is necessary to navigate the research agenda towards sustainable outcomes. Setting research priorities is a formal procedure to generate consensus between different stakeholders on research questions considered a priority for resources allocation (Viergever et al., 2010). Researchers, policymakers and other stakeholders can effectively target research that has the greatest potential benefits, optimizing the allocation of limited resources. A rational and transparent formulation of research priority questions would prove useful for many local food systems, especially in low- and middle-income countries (LMICs) that are most affected by a poorly functioned food system. Nevertheless, paucity of detail about the priority setting process and lack of transparency is common across many LMICs (Tomlinson et al., 2011).

Although priority-setting exercises have been well-documented in nutrition and health domains (Viergever, 2010; Tomlinson et al., 2011; McGregor et al., 2014; Mador et al., 2016; Timotijevic et al., 2019), such a process for food system research has been rare. Recent examples include the works by De Brauw et al. (2019), Raneri et al. (2019) and Gebru et al. (2018). However, these working papers stopped at the list of research questions, without a reflection of the priority setting process. Food system research requires a unique approach to respond to interconnected challenges and constraints, as food systems encompass multiple sectors and multiple disciplines (Ruben et al., 2018), multiple domains, including not only dietary outcomes, but also health, sustainability and socio-economic outcomes (HLPE, 2017), and involves a large amount of interdisciplinary data (Battersby, 2020). This makes priority setting for food systems research a more involving task than priority setting for a single research domain. As the body of work on food system research has grown exponentially (Béné et al., 2019; Fanzo et al., 2020), an analysis of the priority setting process would be helpful for future endeavors to avoid the research waste, which involves ignoring of the needs of potential users of research evidence and overlooking what is already known or already being researched (Chalmers et al., 2014). To fill this research gap, this paper addresses the following research

questions: What are the best practices from health and nutrition priority setting that food systems research priority setting (FSPR) can adopt? What has to be adjusted or complemented to account for the requirements of food systems research?

To illustrate the process of research prioritization for a local food system, we took Vietnam as a case study. Vietnam is a middle-income country that offers a vivid example of local food systems in rapid transformation. During the country's steady economic growth following the economic reforms in 1986, the average caloric intake increased in almost all regions of the country, protein-rich consumption increased, and the prevalence of undernutrition was lowered (Molini, 2006; B. K. Le Nguyen et al., 2013). At the same time, Viet Nam has been observing the transition from traditional diets towards unhealthy food consumption patterns such as high consumption of salt, ultra-processed foods (including instant noodles) and sweetened non-alcoholic beverages, as well as lower consumption of fresh fruit, vegetables and seafood (T. T. Nguyen and Hoang 2018). The food system factors behind these diet transformations have been linked the country's increased prevalence of overweight and obesity (Do T.P. Ha et al. 2011) and an increased burden of disease and prevalence of NCDs (Bach Xuan Tran et al. 2018), all of which increase pressure on the national health care system (T. T. Nguyen and Hoang 2018). Viet Nam's rapid urbanization rate, which is expected to remain above 3 percent annually, and the country's now globally integrated economy, whose trade volume accounts for 178 percent of its GDP (World Bank, 2017), will continue to be catalysts for the nutrition transition currently underway. These dynamic drivers make Vietnam an excellent case study for applying the food systems frameworks to identify research priorities in a local food system. The FSRP process in Vietnam can offer many relevant discussions to improve the overall approach across different contexts.

Following this introduction, the chapter is structured as follows: the next section briefly describes the approaches used in priority setting, how FSRP can learn from them and the additional challenges involved in FSRP. The next section describes the process of FSRP in Vietnam. The final section discusses the lessons learnt, recommendations and conclusions.

2.2. Priority Setting for Food systems Research

While there is no golden standard for priority setting, good practices have been documented, most dominantly in health research (Montorzi et al., 2010; Viergever et al., 2010). In this section, we give a brief overview of the approaches used in priority setting, discuss their relevance for FSRP and the challenges of FSRP.

Best practices in health and nutrition research priority setting

Health research prioritization has a similar goal with that of FSRP. It aims to maximize impact of investments, especially in resource-poor environments, to strengthen health research system and respond to community health needs (Viergever et al., 2010; McGregor et al., 2014). Setting priorities in health research plays an essential role in responding to increased disease burdens and progressing development goals (Chongtrakul & Okello, 2000; McGregor et al., 2014). In FSRP at a global level, it has been pointed out that urgent interdisciplinary research is needed to support concerted policy action in crafting and sustaining food systems to provide nutritious diets for all (Haddad et al., 2016).

FSRP can adopt several approaches used in health research priority setting. Although there is no standard on research priority setting due to varied contexts, the general census is that the processes should be fair, legitimate, evidence-based, inclusive of a broad spectrum of stakeholders, and transparent (Tong et al., 2019). For example, Viergever et al. (2010) proposed a checklist for health research priority setting and outlines nine common themes of good practice to assist health research prioritization processes before, during and after undertaking priority setting (Figure 2). Reviews of health research priority setting exercises have been conducted in both high income countries and LMIC settings (Bryant et al., 2014; McGregor et al., 2014). In a variety of LMICs, the most common process to elicit priorities was a workshop/conference without any explicit specification of established research priority setting methods (24%), followed by the Child Health and Nutrition Research Initiative (CHNRI) method[1] (18%) and a stepwise process including a literature review, in-depth interviews and

[1] The CHNRI method uses a systematic approach to listing a large number of possible research ideas, using the "4D" framework (description, delivery, development and discovery research) and a well–defined "depth" of proposed research ideas (research instruments, avenues, options and questions), well–defined context and criteria, and consensus development through measuring collective optimism among a larger group of experts (Rudan, 2016)

consultation (18%). The application of criteria to determine research priorities was used in 67% of reports.

Preparatory work
1. Context Decide which contextual factors underpin the process: What resources are available for the exercise? What is the focus of the exercise (i.e. what is the exercise about and who is it for)? What are the underlying values or principles? What is the health, research and political environment in which the process will take place?
2. Use of a comprehensive approach Decide if use of a comprehensive approach is appropriate, or if development of own methods is the preferred choice. These approaches provide structured, detailed, step-by-step guidance for health research priority setting processes from beginning to end.
3. Inclusiveness Decide who should be involved in setting the health research priorities and why. Is there appropriate representation of expertises and balanced gender and regional participation? Have important health sectors and other constituencies been included?
4. Information gathering Choose what information should be gathered to inform the exercise, such as literature reviews, collection of technical data (e.g. burden of disease or cost-effectiveness data), assessment of broader stakeholder views, reviews or impact analyses of previous priority setting exercises or exercises from other geographical levels.
5. Planning for implementation Establish plans for translation of the priorities to actual research (via policies and funding) as a priority at the beginning of the process. Who will implement the research priorities? And how?
Deciding on priorities
6. Criteria Select relevant criteria to focus discussion around setting priorities
7. Methods for deciding on priorities Choose a method for deciding on priorities. Decide whether to use a consensus based approach or a metrics based approach (pooling individual rankings), or a combination.
After priorities have been set
8. Evaluation Define when and how evaluation of the established priorities and the priority setting process will take place. Health research priority setting should not be a one-time exercise!
9. Transparency Write a clear report that discusses the approach used: Who set the priorities? How exactly were the priorities set?

Figure 2. Checklist for health research priority setting (Viergever et al., 2010: 3).

Hofmarcher et al. (2017) makes the distinction between setting priorities for health information research and setting priorities for health intervention or healthcare provision. In selecting an optimal portfolio of health interventions, programs or policies, the traditional economic approach can be utilized by ranking programs according to their cost-effectiveness ratio. Other quantitative approaches such as simulation modelling, optimization methods and integrated assessment modelling have been used in supporting priority setting in agricultural research (Thornton et al., 2018). Difficulties in ranking (prioritizing) include limitations in economic evaluation methodology, incorporating equity principles, and practical constraints (Hauck et al., 2015). Although measuring the ex-post impacts of research with quantitative metrics and qualitative narratives is possible, ranking research priorities with economic

evaluation is not feasible ex-ante, as the pathways from research to impact are hard to quantify. Almost 70% (2110) of the identified research priorities at the World Health Organization were developed without using any additional criteria, besides literature review and expert consultation, to rank the priorities with respect to potential public health impact, feasibility of undertaking the research or cost (Terry et al., 2018).

In health priority setting, there was limited evidence of any implementation or follow-up strategies after the priority setting process. Initial identified challenges included engagement with stakeholders, data limitations through limited published information available, and limited capacity to implement research priorities (McGregor et al., 2014). As we will explain in the next section, overcoming this challenge would also play an important role in FSRP.

Within health research priority setting, nutrition research priority setting is an area in particular adjacent to food systems, as its topics of outcomes are also among the key outcomes of food systems. A review by Hawwash et al. (2018) mentioned 53 papers in nutrition priority setting, covering a range of topics such as obesity, wasting, stunting, malnutrition. Most papers used a combination of methods, including debates and discussions, Delphi process, and CHNRI. The majority of the papers did not describe follow-up activities of the proposed priorities. Following this finding, and amidst the concern about research waste, Hawwash et al (2021) assessed how priority setting exercises for research are considered in publication. They found that although half of the priority setting exercises' authors were positive about their priority setting exercise impact, priority setting exercises are rarely cited for the purpose of acting on the proposed research priorities. Key identified barriers for uptake of research priories were challenges in involving stakeholders and the general public for participation in the priority setting exercise (Hawwash et al., 2021). It was proposed that the presence of the funders and guided discussion between funders, researchers, and other stakeholders at the beginning of the priority setting exercises; and knowledge transfer between different priority setting exercises could help to increase uptake of priority setting exercises' recommendations. This proposal is particularly relevant for FSRP, which is a fairly new exercise.

Challenges of setting priority for food system research

Despite sharing similarities with health and nutrition research, food systems research has several characters that makes FSRP a more challenging task.

Food systems encompass multiple sectors and multiple disciplines (Figure 3). Food systems analysis asks for support from a wide variety of disciplines and also requires the involvement of multiple stakeholders, including the engagement of other (non-science) parties in the research process (Ruben et al., 2018). In health research, it's possible to set priorities for sub-domains such as early child development and violence prevention (Rudan et al., 2010; Tomlinson et al., 2017) and aging (Doolan-Noble et al., 2019). Although breaking down food systems into several domains may be an attractive option, one can lose sight of the synergies and trade-offs that are inherent among the components of the food systems (HLPE, 2017; Béné et al., 2019). The broad multi-stakeholder cooperation and knowledge exchange is particularly important to consider the full spectrum of food system research. The myriad parts of the food system can have interactions with each other, and the vast amount of work is needed to make even small changes. Therefore, nutrition, public health, agriculture, and the food industry need work together to solve interconnected problems (Finley et al., 2017). As a result, challenges with stakeholder engagement faced by health research priority setting exercises (McGregor et al., 2014; Hauck et al., 2015) will be even more prominent in food system research priority setting.

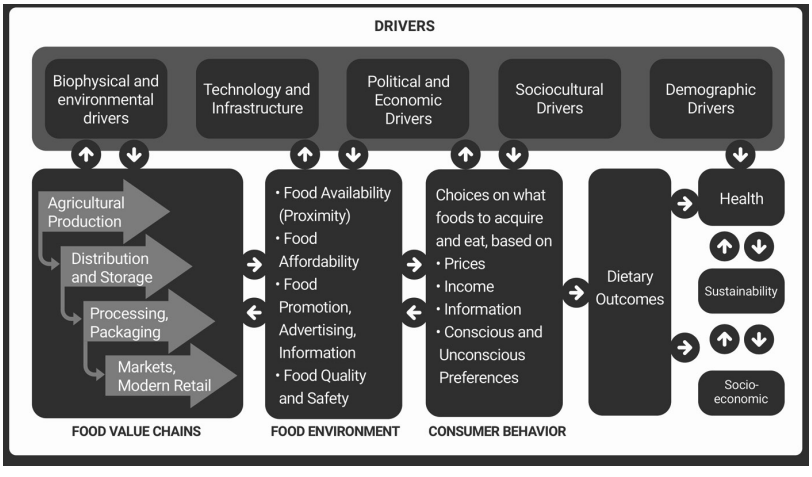

Figure 3. *Food systems components (de Brauw et al., 2019: Fig 2, adapted from HLPE (2017))*

Food system outcomes cover multiple domains, including not only dietary outcomes, but also health, sustainability and socio-economic outcomes (HLPE, 2017). Assessing the benefits and costs of a food system intervention is therefore complicated, thus making the judgement on the priority level of a research initiative difficult. For example, severity of the outcome of a disease burden, a common criterion used in health research priority setting, would have to be tweaked to account for several outcomes. A healthy diet for consumers should also seek to promote synergies between health and sustainability (Béné et al., 2019). As multiple stakeholders are motivated by different incentives, defining a set of selection criteria among stakeholders to account for different outcomes is puzzling. To illustrate, investments in better waste management (environmental outcome) tend to increase overall market availability that leads to lower producer prices (socio-economic outcome), thus taking away the initial incentive for engagement by producers.

Due to its large coverage, food systems research involves a large amount of interdisciplinary data. This means that the step of information gathering as a preparatory step for determining research priorities demands significant time and coordination. The required data include not only data pooled from different sectors, but also from different time points, due to adaptive processes and dynamic drivers of the food systems. Defining the boundary for literature and data gathering is therefore important. A recent data effort to characterize available food system data from Viet Nam indicated that while there are few primary datasets with repeated use of instruments, access options for the majority of datasets was unclear and dependent on the data producing institution (the authors could access less than half of the raw data), and data on food processing and distribution and food loss and waste were lacking (Burra et al., 2019). Data collection to inform FSRP therefore requires flexible approaches, including secondary data review and consultation with experts and policy makers to approach relevant data producing institutions.

2.3. Research Prioritization Process in Viet Nam

Setting research priorities for Viet Nam local food system was by researchers as part of the efforts to characterize the food system[2]. Instead of limiting the process to a researcher-led exercise, the researchers took this opportunity to involve national stakeholders in setting research priorities for food systems in Viet Nam. An increasingly diverse group of stakeholders joined towards the end of the priority-setting exercise. The multidisciplinary multi-stakeholder approach serves the following objectives: First, to align the research activities with the policy interests; second, to sensitize stakeholders with the food system approach; and third, to increase uptake of research results through joint ownership of the research agenda.

Although the process to determine priority research and action areas in Viet Nam did not follow a standard approach, it can be divided in three main stages: preparatory work, determination of research priorities, and follow-up (Figure 4). After we trace the activities at each stage in this section, we could reflect on how the process followed or deviated from the suggested good practices of research priority setting (Viergever et al., 2010; Mador et al., 2016) in Discussion.

[2] The exercise was part of the flagship Program Food Systems for Healthier Diets (FSHD), CGIAR Research Program on Agriculture for Nutrition and Health (A4NH) portfolio. FSHD focuses on food systems through the agri-food value chains impact pathway and the associated policy enabling required to accelerate food system innovation, scaling, and anchoring. A core group of researchers from WUR, Bioversity, CIAT and ILRI were tasked with initiating this activity.

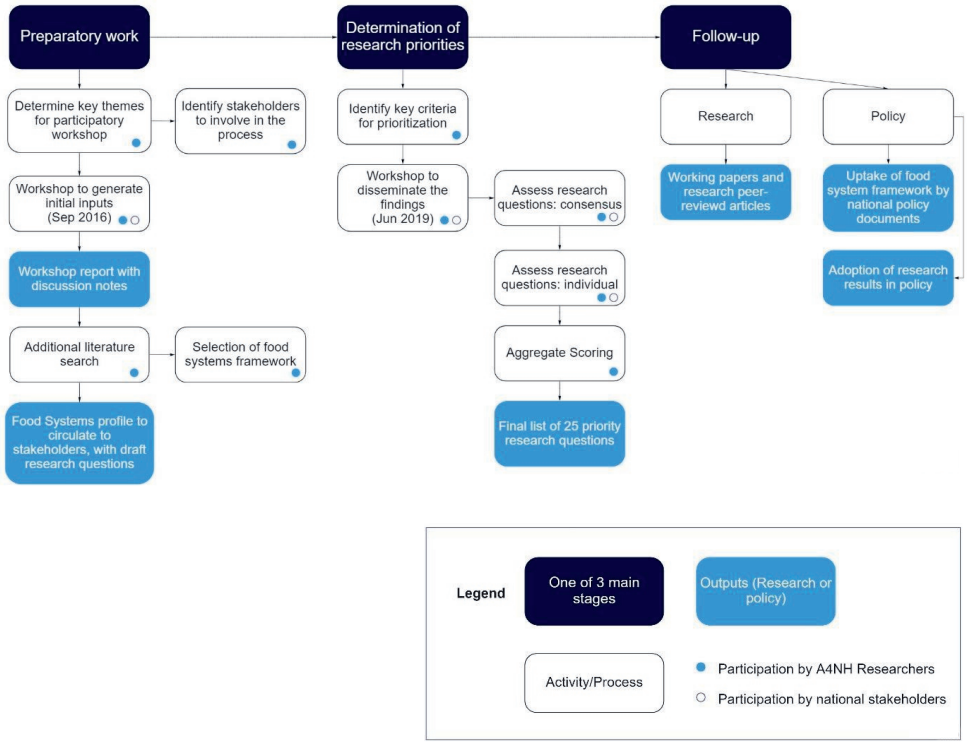

Figure 4. *Research priority setting process (Source: authors)*

Preparatory work

From the beginning, stakeholder representatives that needed to be involved in the research priority setting exercise were identified and invited to the co-planning workshop in September 2016. In this workshop, besides researchers from within the initiating program A4NH (CIAT, IFPRI, ILRI, WUR) and outside A4NH with presence in Viet Nam (CASRAD, FAVRI, CIRAD), different sectors and constituencies were involved: civil society (Health Bridge, GAIN), policymakers (National Institute of Nutrition, Ministry of Industry and Trade), funders/donors (FAO), and the private sector (Fresh Studio). The invited stakeholders who would like to contribute in the next stages of the priority setting process were also identified here.

To prepare for the co-planning workshop, the researchers carried out a rapid identification of the main themes related to Viet Nam's food systems to facilitate brainstorming and discussion.

These themes were (i) Healthy Diets, (ii) Value Chains, (iii) Policy, and (iv) System Dimensions. The first two themes are integral to any food systems framework. The third theme was selected in particular to examine the potential of aligning the research priorities with policy implementation. The objective of the fourth theme was to grasp how the current systems lens was adopted by stakeholders. In the workshop, the participants were divided in four corresponding groups. Each group discussed, identified and prioritized key research & development areas to be addressed, considering the Vietnamese context and perceived user demands. The findings of these group discussion were summarized in an internal report that represents the first output of the research priority setting process.

The researchers then used the entry points provided by the planning workshop report, including key words and research questions identified by participants, as the primary inputs for further analysis of the literature and secondary data analysis. Combined with the global food systems frameworks to characterize the food systems in Viet Nam, additional literature was consulted to create a national food systems profile. The modern food system framework covers all the elements (environment, people, inputs, processes, infra- structures, institutions, etc.) and activities involved at such stages, including a more detailed breakdown of food system drivers (CIAT, 2017; Global Panel on Agriculture and Food Systems for Nutrition, 2017; HLPE, 2017; Béné et al., 2019). The main domains for the research priorities are in line with the main components of this framework (Figure 4): Food Value Chains (Food Supply), Food environment, Consumer behavior, Drivers, and Trade-offs and Synergies. While the first four domains come directly from the framework, the last domain was chosen for the growing public concern and its increasingly integral role in the food systems approach (Ingram, 2011; Global Panel on Agriculture and Food Systems for Nutrition, 2016).

Besides the core writing team of researchers, a multidisciplinary team of co-authors (those identified during the planning workshops) were mobilized to review a large amount of existing data sources to create the food system profile and identify research gaps. An example of research gap finding in the Drivers section is included in Appendix 1 of this paper. This step took significant time, given the scope of the exercise and the large number of co-authors involved, as well as the data gaps. The connection with government partners in the research network, for example the General Statistics Office, was utilized to gain access to data and

ministerial level documents that were not available to the public. Together, the coauthors developed a draft set of questions based on research gaps arising from the food system thematic areas corresponding with each section of the food systems profile.

As the final step of preparatory work, as an example for practical application of the research priorities, the researchers who initiated the exercise also classified priorities into themes that fit within the framework of their research program[3].

Determination of priorities

In identifying research priorities, two key criteria were used. First, Viet Nam's prioritized research questions should align with existing international and global agendas on food systems research. In particular, the research questions should directly contribute to building the evidence base to strengthen policies that emphasize 'high quality diet', building more data and metrics for diet quality and food systems, better evaluation of policies and policy actions, climate accounting, and incentive structures (Global Panel on Agriculture and Food Systems for Nutrition, 2016; IFPRI, 2016). Secondly, national priorities as outlined in key policy documents were acknowledged and accounted for.

In assessment of the research priorities, an approach that combines consensus with metrics was used. The stakeholder workshop provided a consensus on the broad themes and key elements of the food systems. The Viet Nam food system profile, with the draft set of priority research questions, was circulated to a wide range of stakeholders for review prior to a participatory stakeholder workshop that took place in June 2019. Stakeholders were invited to provide their feedback externally to the planned workshop if they were unable to participate on the day of the workshop. In this participator stakeholder workshop, besides the draft list of research questions, which were grouped into themes, the participants brainstormed additional research questions or identified areas that required additional elaboration. Participants then broke up into parallel working groups, to further refine and add to the set of proposed questions. These questions then went through a prioritization exercise, where stakeholders were asked to individually identify their top 15 priority research questions, across all thematic

[3] The A4NH's implementation plan for the flagship Food Systems for Healthier diets involves three clusters of activities: Diagnosis and Foresight, Food Systems Innovation, and Upscaling and Anchoring of Food System Transformation

areas. Appendix 2 shows the results of the full ranking and the prioritization of all questions within each thematic area.

The first product of the research priority determination process was a food system profile for Viet Nam, using the aforementioned framework. Raneri et al. (2019) provides the full food system profile characterization for Viet Nam (Raneri et al., 2019). Table 1 presents the list of prioritized research questions. While there was not a big difference in the number of priorities across the domain, food supply has the most number of questions (8), followed by synergies and trade-offs (7), nutrition and consumer behavior (6), drivers (5), and the food environment (4).

Table 1. *List of Prioritized research questions*

Priority Ranking Order for Action	Research Question	Domain	Priority Order by Vote
1	What are the trade-offs and associations between agricultural production, health, environment (including agrobiodiversity and ecosystem services), and economic outcomes?	Synergies & trade-offs	1
2	How to work with the private sector to promote healthy diets? What policies are necessary to regulate the private sector to promote health?	Food environment	2
3	What is the potential of smallholder-oriented innovations in the food distribution systems?	Food supply	3 (tie)
4	How can we improve the management system/governance of food supply in Viet Nam?	Food supply	3
5	Can healthier food choices lead to a healthier food supply?	Food supply	3
6	What are the trade-offs between food safety, food waste, nutrition and environment?	Synergies & trade-offs	3
7	What is the role of street food in Vietnamese diets and its nutritional outcomes?	Nutrition and consumer behavior	7 (tie)
8	What should Viet Nam do to promote healthy and diverse diets within the context of trade (liberalization, imports, foreign investments)?	Synergies & trade-offs	7
9	How are the interactions/dynamics between family, school and communities ensuring healthy diets for children?	Food environment	8 (tie)
10	What are the costs and benefits for smallholders associated with the rise of different distribution and retail outlets?	Food supply	8

Priority Ranking Order for Action	Research Question	Domain	Priority Order by Vote
11	What are some options to make modernization of the supply system more inclusive?	Food supply	8
12	How do food policies interact with the determinants of obesity and NCDs?	Food environment	9 (tie)
13	What are the weak points along the supply chain regarding food loss management?	Food supply	9
14	What interventions targeted at smallholders can improve food supply systems in Viet Nam?	Food supply	9
15	Who are the winners and losers regarding environment, economic, health and nutrition outcomes of food-related opportunities brought about by urbanization?	Synergies & trade-offs	9
16	To what extent, and how, are food system-related matters considered in urban planning?	Drivers	16 (tie)
17	How does the governance system (and its new laws, policies, etc.) affect the food system?	Drivers	16
18	How does trust (e.g. food safety, traceability, etc.) affect consumption behavior?	Nutrition and consumer behavior	16
19	What are the synergies and opportunities between the drivers of food system change?	Synergies & trade-offs	16
20	How has climate change influenced the nutrition transition in Viet Nam?	Drivers	20 (tie)
21	How to harness the role of traditional beliefs and practices to improve diets (e.g. of ethnic community communities)?	Drivers	20
22	How do new consumption trends and norms (e.g. vegetarianism, clean eating, etc.) affect the food system?	Drivers	20
23	What are the effects of marketing campaign strategies from the private sector on diets and health?	Food environment	20
24	What are storage knowledge gaps of farmers and traders?	Food supply	20
25	What are the major nutrition-sensitive agriculture promotion strategies best suited for improving healthy diets, among general population, particularly 'vulnerable' groups including migrants and minority ethnic?	Nutrition and consumer behavior	20
26	What are child and adolescent initiated interventions that promote healthier diets at household, school and media levels?	Nutrition and consumer behavior	20

Priority Ranking Order for Action	Research Question	Domain	Priority Order by Vote
27	How can food labeling initiatives have positive effects on the food system? Specifically, how can they improve consumer knowledge and empower consumers to make healthier food choices while also creating demand for healthier and safer food options from food companies?	Nutrition and consumer behavior	20
28	How can emphasizing increasing consumer demand help shape or change production patterns to be more sustainable? What are the demand and supply incentives that are needed?	Synergies & trade-offs	20
29	Have dietary consumption patterns followed agricultural production patterns or vice versa? How could the demand and supply relationship between production and consumption be better understood to shape healthier food systems, through shaping both agriculture and nutrition policies?	Synergies & trade-offs	20
30	What is the evidence of health benefits/harm of modernized diets compared to traditional ones?	Nutrition and consumer behavior	30

After the first planning workshop in 2016, the National Institute of Nutrition expressed the wish for deeper involvement with the network and an MOU was signed to facilitate A4NH's work on food systems research and the national institute. This marked the involvement of a national agency directly in charge of consulting health and nutrition-related issues for the Government in A4NH, which is expected to help disseminate the findings and policy recommendations to a higher level.

Follow-up to the identification of research priorities

To ensure transparency, the result of the food system profiling and priority setting exercise was disseminated via the A4NH network and its partners, as well as published as an IFPRI discussion paper. As a follow up, this article was prepared to document the process in more detail, as well as assess how far the research priorities have been addressed to date. At the end of 2020, a quick survey of the stakeholders involved in the determination of priorities was carried out during a national year-end meeting to collect relevant research outputs. By the end of FSHD, a stock taking activity is planned to reflect on what the program has achieved in alignment with the identified research priorities.

Research follow-ups

At the time of writing, according to our knowledge, a quick check using Google Scholar citations of the working paper, and the survey of stakeholders at the end of 2020, a number of research outputs have aligned with the list of priority research questions. For example, the need for priority research question (RQ) number 9 "How are the interactions/dynamics between family, school and communities ensuring healthy diets for children" was responded by a study testing methods for healthier consumption in schools (T. Nguyen et al., 2020). Other examples include:

RQ 6: New insights on the nexus of diet-related environmental impacts, food sourcing, and food choice motives along rural – urban population transect: Evidence from Vietnam (Huong Trinh et al, 2021).

RQ7: Factors Associated with Food Safety Compliance among Street Food Vendors in Can Tho City, Vietnam: implications for intervention activity design and implementation (CISED, 2020)

RQ8: Tensions and coalitions: Trade agreements and the policy space for nutrition in Vietnam (Harris et al forthcoming); Nutrition transition in Vietnam: changing food supply, food prices, household expenditure, diet and nutrition outcomes (Harris et al., 2020).

RQ12: Child overweight or obesity is associated with modifiable and geographic factors in Vietnam: implications for program design and targeting (Ty Beal et al. 2020).

RQ15: Food policy and the unruliness of consumption: An intergenerational social practice approach to uncover transforming food consumption in modernizing Hanoi, Vietnam (S. C. O. Wertheim-Heck & Raneri, 2020).

RQ20: Nutrition landscape and climate in Vietnam: Identifying climate service entry points (Singh et al., 2020)

This list is not exhaustive, as it only registered studies that were reported by participants joining the workshop at the end of 2020.

Uptake of research in policy

The A4NH Country Coordination and Engagement Unit (CCE) has employed the food framework mentioned in the paper to share and engage with Zero Hunger (ZH) National Action Plan in Vietnam. A4NH has involved for a year as a member in the technical working group of ZH to facilitate on nutrition sensitive work for the ZH implementation. Recently, the Ministry of Agriculture and Rural Development (MARD) has approved a training material for ZH staff on nutrition sensitive work in which the framework in the paper is credited in the training materials[4] (Figure 5).

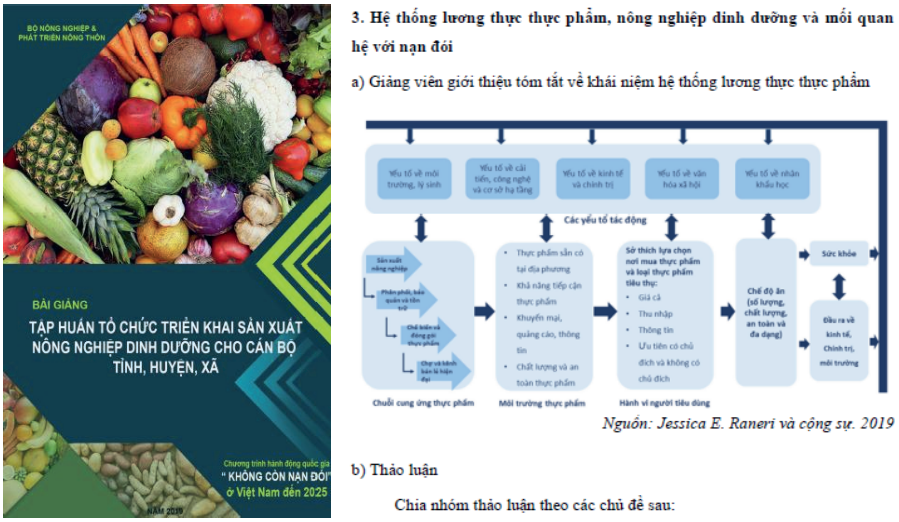

Figure 5. *Use of food systems framework in MARD training material for ZH (Source: Bioversity-CIAT 2020)*

As of mid-2021, Bioversity-CIAT alliance is preparing food systems priority-setting workshops at the local level for three urban-peri-urban-rural districts in Viet Nam. These workshops follow the framework of the national priority-setting exercise, with a stronger focus on actions (projects, programs and policies) taken at the local level that can come from research results. The food systems profiles for these three districts, which were developed beforehand based on research, would be shared in these workshops.

[4] https://blog.ciat.cgiar.org/update-food-systems-for-healthier-diets-a4nh-contributions-to-the-nutrition-sensitive-movement-in-vietnam-continue/

2.4. Discussion and Conclusion

This paper has described in detail the priority setting process for research on local food systems in Viet Nam. The 3-year process was inclusive, involving a large number of stakeholders from different sectors at different stages. Using a modern food system framework, the researchers and multisector stakeholders prepared a food systems profile for Viet Nam to take stock of the current evidence base, identify research gaps and propose priorities for research. The final list of research priorities was developed based on aggregation of individual stakeholders' rankings. Initial research actions have been taken up based on the list of research priorities, although not all research questions have been tackled. Follow-up policy involvement has been initiated. The process achieved initial success in sensitizing local stakeholders about the food systems approach, which has been adopted by official documents approved by potential policy makers.

In achieving these results, the process has adopted several good practices from health and nutrition priority setting. First, during preparatory work, the exercise pooled a large amount of data and an extensive literature review to understand the context, which was condensed into a food system profile for Viet Nam. Investment in additional research should always be preceded by systematic assessment of existing evidence (Chalmers et al., 2014). This was the second study in the series by the initiating research program that seeks to identify research priorities at the national level, following the case of Ethiopia (Gebru et al., 2018), filling an important gap in priority setting for food systems. The expansion of this exercise, which is mostly practiced in health research, into food systems research will help to generate new lessons and key themes of good practice can start to emerge. During the exercise, synergies and trade-offs in the local food system were discussed (Raneri et al., 2019), making the review exercise more than a mere sum of the literature reviews on individual components of food systems. Second, it had a clear method for deciding on priorities, which was a combination of consensus-based (during the workshop's participatory discussions) and metrics-based (pooling individual rankings in a survey) approach. Third, the process was inclusive and transparent, with all outputs circulated to workshop participants, shared with extended group of stakeholders for feedback, finalized and published as working papers after priorities have been set. While the exercise was put within the framework of A4NH as a research initiative, the inclusion of ministerial representatives, government agencies and stakeholders outside the network gave opportunities to broaden the impact of the priority setting exercise.

The process could benefit from a number of improvements. First, in assessing priorities, FSPR in Vietnam only had a minimal list of criteria, without quantifying these criteria. Criteria are used to focus discussion around research priorities and to ensure that important considerations are not overlooked. They also depend on identified values or principles of the exercise (Rudan et al., 2010). Identifying a set of criteria requires an inclusive process, which we did not have the resources to carry out. Therefore, instead of coming up with our own set of criteria, we gave more freedom to the stakeholders in determining what they found most important to them, thereby not imposing researcher-biased criteria on the stakeholders. As expected, participants did not raise any issue with the lack of clear-cut criteria. They simply used their personal expert judgement to select the priorities. Nevertheless, this lack of criteria has resulted in difficulties in assessing the research outputs. Indeed, we could not measure the research and policy outputs against any metrics to assess if they responded well to the issues in consideration. We could only map the research to the appropriate topics. In the follow-up priority setting exercises at the district level, with time resource allowed, more clear criteria would be available for respondents. FSPR can consider the criteria that have been used in health priority setting exercises, which can be at the population level (including burden, equity and efficacy and effectiveness), health systems level (workforce, political context and delivery), and research process and feasibility (knowledge generation, ethics, relevance, funding) (McGregor et al., 2014). Without a strict set of criteria, it is not surprising that some of the research questions (for example: “Can healthier food choices lead to a healthier food supply?) are abstract and overarching. Narrowing down the research scope to more “researchable” questions therefore was challenging and would hinder implementation.

The second key improvement that future FSPR has to consider is broadening the list of stakeholders to various fields. In Vietnam, although the exercise involved various stakeholders, representatives in nutrition and health were overrepresented among policy stakeholders, while the food systems approach requires a multidisciplinary joint effort. It was fortunate that this overrepresentation did not bias the list of research questions. In fact, the domains with the most prioritized research questions were food supply chains and synergies and trade-offs, which require a holistic lens. Apparently, to date we have not recorded any research outputs that tackled the top 5 research priorities, which are highly multidisciplinary in nature. The presence of stakeholders from more fields and expertise would have provided some practical

suggestions on how to tackle the research questions. Future endeavors should seek to increase the limited presence of the private sector, which acts as the central driver the 'missing middle' between production and consumption. This issue has also been observed in priority setting for health research (McGregor et al., 2014). Additionally, the underrepresentation of the public was also a drawback. There is a need to foster bottom-up approaches where priority setting exercises are led by citizens and affected members of the society instead of only academics (Sanders et al., 2004). Admittedly, attracting the public in academic-led discussions and workshops has always been challenging and not common (Tomlinson et al., 2011; McGregor et al., 2014). The next priority-setting exercises at the district level would enable more participation of the public.

Finally, yet importantly, the priority setting would benefit greatly from a more concrete follow-up plan. All the work so far on FSPR by de Brauw et al. (2019), Raneri et al. (2019) and Gebru et al. (2018) did not present or provide a follow-up to the priority exercises. It's important to not only focus on transparent research priority setting, but also provide follow-up and evaluation of such an initiative (Chalmers et al., 2014). Planning for implementation should already be done during the initial phase of a research priority setting exercise, especially where priorities are set by those not directly responsible for their implementation (Viergever et al., 2010). Our exercise produced an extensive and ambitious list of research questions, which could not be handled within the scope of a single research program. Besides, no one was designated to implement the priorities. It has also been argued that priority setting processes must have in-built mechanisms for publicizing results (Tomlinson et al., 2011). Although A4NH has had some initial studies and policy output that are part of the priorities, taking stock of all the research activities in Viet Nam that has addressed the priorities requires substantial effort. It is therefore recommended that the program, from the beginning, have a plan to reach out beyond its network to distribute the priorities and cover more research actions. A plan to monitor how the research priorities are addressed across sectors nationwide should be in place. In the plan, measures to assess the impacts of the research agenda should be clarified, as influence of research priority setting efforts may well go beyond citation of literature or tacit uptake in policies and practice (Sarli et al., 2010; Cruz Rivera et al., 2017).

Assessment of the uptake of priority setting exercises is a challenging task. In this paper, we based the initial assessment of research results only on our own knowledge and a quick survey of stakeholders and provided simple measures of research-related impacts. Assessing research impact may also involve methods such as citation analysis research, meta-analysis, evaluation of interventions or technology, capacity building and academic collaborations, and data sharing (Cruz Rivera et al., 2017). Having a clear plan and specifying the expected impacts of the priority setting exercise would enable more meaningful follow-ups.

In conclusion, setting priorities for food system research is an involving activity, requiring extensive preparation work, high commitment from multidisciplinary stakeholders and a robust mechanism for planning, monitoring and evaluation. Nevertheless, the process and lessons learnt we described in this paper could serve as useful starting points for future similar endeavors. It would be useful to draw up a comprehensive approach as a step-by-step manual for facilitators of a national priority setting process. Building on the experiences of priority setting exercises in health and nutrition, the approach must also take into account the characteristics and challenges of food systems research and analysis.

Appendices

Appendix 1. Identification of research questions and hypotheses for "Drivers" domain:

Global driver	Observed or expected transition or transformation[5]	Local transition or transformation in Vietnam	Literature	Pending research questions	Hypotheses
Urbanization and related changes in lifestyle	Increase in demand for (ultra)-processed food	Similar as global	Reardon et al., 2014 Vo & Smith, 2017 S. Wertheim-Heck et al., 2019 Le Ngoc Dien et al., 2004; Lachat et al., 2009; V. Mishra & Ray, 2009	How is urbanization affecting the welfare of different stakeholders along the food supply chains (e.g. consumers, vendors, farmers?)	Massive agribusiness opportunities for local farmers and producers, but also for importers and retailers (Tschirley, 2017)
Raise in consumers' income	Increase in demand for animal-based protein	Similar as global	T. T. Nguyen & Hoang, 2018 Hansen, 2018		
	Increase in demand for (ultra)-processed food	Similar as global	General Statistics Office of Viet Nam, 2016 S. Wertheim-Heck et al., 2019		
	Increase in overall demand for food	Similar as global Inequality across regions and between non- and non-poor households	Glewwe et al., 2004; Le Ngoc Dien et al., 2004; Nguyen Minh Thang & Popkin, 2004; Molini, 2006; V. Mishra & Ray, 2009 General Statistics Office of Viet Nam, 2016		
Population growth	Increase in overall demand for food	Similar as global	Hoa K. Hoang & Meyers, 2015	How does internal migration affect food system outcome?	

[5] For the list of literature, see Bene et al. (2019)

Global driver	Observed or expected transition or transformation[5]	Local transition or transformation in Vietnam	Literature	Pending research questions	Hypotheses
		In Vietnam, high internal migration rate, a young but at the same time aging population are driving the food systems			
Growing attention paid to diet and health issues	Expected decrease in the prevalence of diet-related non-communicable diseases	Not yet In fact, NCDs are still on the rise Some signs have been observed in cities and among high income consumers	Bui et al., 2016 Kantar research 2019	How is increasing attention paid to diet and health issue driving the prevalence of NCDs for Viet Nam in the future?	The expected positive trend is mostly observed for high income groups who can afford healthy diet (which is usually higher than that of an unhealthy diet) (Rao et al., 2013)
Technological innovations (mechanical, irrigation, plant breeding, management of inputs, or access to knowledge	Increase in per capita agricultural outputs	Similar as global	Friederichsen et al., 2013 World Bank, 2016 Takeshima et al., 2018	How is Vietnam's commitment to high-tech agriculture (aka Agriculture 4.0) potentially contributing the food system outcomes?	Agriculture 4.0 is likely to change the way agricultural supply chains function, and the ways in which products are composed by food manufacturers, sold by retailers, bought by end-consumers, and food waste is prevented (Klerkx & Rose, 2020)
Intensification and homogenization of the agricultural sector	Increase in per capita agricultural outputs	Similar as global	World Bank, 2016		
	General degradation in soils and agro-ecological conditions		Vu Chi Cuong, 2014 Hoi et al., 2016 World Bank, 2016 V. C. Nguyen, 2017		

Global driver	Observed or expected transition or transformation[5]	Local transition or transformation in Vietnam	Literature	Pending research questions	Hypotheses
			Dinh, 2017 Hedberg et al., 2018		
Climate-change: progressive increase in a) air temperature, b) frequency and intensity of extreme events	Expected decrease in agricultural production of several key crops	Similar as global Climate change impacts are affected differently across regions given the tremendous biophysical and economic variations across regions	Yu et al., 2010 Haggar & Schepp, 2012 Ovalle-Rivera et al., 2015 Trieu & Phong, 2015 World Bank, 2016 Trinh, 2018	How has climate change been influencing the nutrition transition in Viet Nam? How do climate coping strategies, e.g. adoption of climate smart interventions, affect the food systems, e.g. agricultural production and outcomes?	Climate change exacerbates undernutrition, especially among the most vulnerable populations, as nutritional quality from crops decreases (e.g. protein, iron, and zinc deficiencies increase) (Fanzo et al., 2018)
General degradation in soils and agroecological conditions	Expected decrease in agricultural production of several key crops	Similar as global	Vu et al. (2014) Tilahun et al., 2018 (Land Degradation Neutrality Working Group, 2018	How have degradation in soils and agroecological conditions contributed to loss of productivity of the food systems?	General degradation in soils and agroecological conditions led to decrease in agricultural production of several key crops (Bindraban et al., 2012)
Improved access to infrastructure (e.g. power grid, roads) and information	Increase the capacity of small and medium size producers to engage in national and international food systems	Similar as global	Mu & van de Walle, 2011 Ministry of Industry and Trade, 2017 Asian Development Bank, 2010; D. Mishra, 2011; Banwatt, 2014 Lançon et al., 2014; H. X. Thanh et al., 2015	How has the overhaul of market infrastructure and logistics in cities been affecting dietary and nutrition outcome? How have infrastructure improvement (e.g. in rural area) influenced dietary and nutrition outcomes for the	

Global driver	Observed or expected transition or transformation[5]	Local transition or transformation in Vietnam	Literature	Pending research questions	Hypotheses
				most advantaged groups?	
	Globalization of the food trade	Similar as global	Viet Nam Ministry of Industry and Trade, 2017 World Bank, 2017 Jung Eun et al., 2019	What are the impacts of infrastructure improvement on domestic consumption and international trade?	
Trade policies and all the other processes facilitating or mitigating trade expansion	Increase the capacity of small and medium size producers to engage in national and international food systems	Limited evidence While the impact has largely been positive for SMEs, smallholder farmers still face constraints	Kokko & Sjöholm, 2005 World Bank, 2016 World Bank, 2017 Nguyen and Jolly (2020)	What have been the impacts of internationalization on smallholder food producers?	
	Globalization of the food trade	Similar as global	N. D. Thanh et al., 2015 Schram et al., 2015 Uiterwijk & Thuc Linh, 2016 World Bank, 2017		
	Increase demand for food quality and safety standards	Similar as global	Uiterwijk & Thuc Linh, 2016 World Bank, 2017	How has trade liberalization influenced the domestic food quality?	In theory, foods that are traded could either harness both quality and safety standards of produce for both export and domestic markets, or they could bifurcate: high-quality products are exported, and low quality remain within the domestic market.

Global driver	Observed or expected transition or transformation[5]	Local transition or transformation in Vietnam	Literature	Pending research questions	Hypotheses
	Supermarketization of food systems	Similar as global Facing resistance from consumers' usual practices	Nielsen, 2013 Nguyen et al., 2013 Nguyen Hai Thi Hong et al., 2013 Coe & Bok, 2018 S. C. O. Wertheim-Heck et al., 2015 CGFAR, 2018 EVBN, 2018		
Internationalization of private investments	Supermarketization of food systems				
Growing concerns for food safety	"supermarketization" of food systems		MoIT 2009 Viet 2014 S. C. O. Wertheim-Heck et al., 2015	What future policies will shape the retail system to adjust growing demand for food safety, while catering to the conventional practices?	

Appendix 2. Full list of research questions organized by rank (per number of votes received) across all food system domains.

Priority	Research Question	Domain	Priority (By Vote)
1	What are the trade-offs and associations between agricultural production, health, environment (including agrobiodiversity and ecosystem services) and economic outcomes?	Synergies & trade-offs	1
2	How to work with the private sector to promote healthy diets? What policies are necessary to regulate the private sector to promote better health and nutrition?	Food environment	2
3	What is the potential of smallholder-oriented innovations in the food distribution systems?	Food supply	3 (tie)
4	How can we improve the management system/governance of food supply in Vietnam?	Food supply	3
5	Can healthier food choices lead to healthier food supply systems?	Food supply	3
6	What are the trade-offs between food safety, food waste, nutrition and environment?	Synergies & trade-offs	3
7	What is the role of street food in Vietnamese diets and its nutritional outcomes?	Nutrition and consumer behavior	7 (tie)
8	What should Vietnam do to promote healthy and diverse diets within the context of trade (liberalization, imports, foreign investments)?	Synergies & trade-offs	7
9	How are the interactions/dynamics between family, school and communities ensuring healthy diets for children?	Food environment	8 (tie)
10	What are the costs and benefits for smallholders associated with the rise of different distribution and retail outlets?	Food supply	8
11	What are some options to make modernization of the supply system more inclusive?	Food supply	8
12	How do food policies interact with the determinants of obesity and NCDs?	Food environment	9 (tie)
13	What are the weak points along the supply chain regarding food loss management?	Food supply	9
14	What interventions targeted at smallholders can improve the food supply system in Vietnam?	Food supply	9
15	Who are the winners and losers regarding environment, economic, health and nutrition outcomes of food-related opportunities brought about by urbanization?	Synergies & trade-offs	9
16	To what extent, and how, are food system-related matters considered in urban planning?	Drivers	16 (tie)
17	How does the governance system (and its new laws, policies, etc.) affect the food system?	Drivers	16
18	How does trust (e.g. food safety, traceability, etc.) affect consumption behavior?	Nutrition and consumer behavior	16
19	What are the synergies and opportunities between the drivers of food system change?	Synergies & trade-offs	16
20	How has climate change influenced the nutrition transition in Vietnam?	Drivers	20 (tie)

Priority	Research Question	Domain	Priority (By Vote)
21	How to harness the role of traditional beliefs and practices to improve diets, e.g. of ethnic minority community communities?	Drivers	20
22	How do new consumption trends and norms (e.g. vegetarianism, clean eating, etc.) affect the food system?	Drivers	20
23	What are the effects of marketing campaign strategies from the private sector on diets and health?	Food environment	20
24	What are storage knowledge gaps of farmers and traders?	Food supply	20
25	What are the major nutrition-sensitive agriculture promotion strategies for improving healthy diets, among general population, particularly 'vulnerable' groups including migrants and minority ethnic communities?	Nutrition and consumer behavior	20
26	What are child and adolescent initiated interventions that promote healthier diets at household, school and media levels?	Nutrition and consumer behavior	20
27	How can food labeling initiatives have positive effects on the food system? Specifically, how can they improve consumer knowledge and empower consumers to make healthier food choices while also creating demand for healthier and safer food options from food companies?	Nutrition and consumer behavior	20
28	How can emphasizing increasing consumer demand first help shape or change production patterns to be more sustainable? What are the demand and supply incentives that are needed?	Synergies & trade-offs	20
29	Have dietary consumption patterns followed agricultural production patterns or vice versa? How could the demand and supply relationship between production and consumption be better understood to shape healthier food systems, through shaping both agriculture and nutrition policies?	Synergies & trade-offs	20
30	What is the evidence of health benefits/harm of modernized diets compared to traditional ones?	Nutrition and consumer behavior	30 (tie)
31	What role does the media play in the food system?	Drivers	30
32	How do the alternative retail channels operate? What are the current policies regulating each? What are the gaps in policy/risks associated with each type of alternative retail market?	Food environment	30
33	How are the food production challenges and how are they influencing diet quality?	Food supply	30
34	What roles can the Vietnamese youth and women (including those from vulnerable groups) play in the food systems (e.g. from a consumption and/or production perspective)?	Drivers	34 (tie)
35	What are the characteristics of food safety interventions and policy in Southeast Asia and LMICs?	Food environment	34

Priority	Research Question	Domain	Priority (By Vote)
36	How is the increasing market share of the private sector influencing children's health and diets?	Food environment	34
37	What are the barriers to consolidation of production systems and what can be done to address the risks associated with consolidation?	Food supply	34
38	How does climate change affect the food supply in Vietnam?	Food supply	34
39	How are more efficient value chains, which are serving the demand of urban consumers, affecting traditional seasonal variations in diets? Does this have an effect on diet quality and cultural aspects of diets?	Synergies & trade-offs	34
40	How are climate change considerations integrated in food and nutrition policy formulation and implementation?	Drivers	40 (tie)
41	What are effective diet interventions for elderly people in Vietnam?	Nutrition and consumer behavior	40
42	What are consumers' conceptions and perceptions on food labelling and the food industry's initiative on food labeling?	Nutrition and consumer behavior	40
43	Can nutrition-sensitive agriculture interventions be effective at reducing sugar intake and the prevalence of NCDs?	Nutrition and consumer behavior	40
44	What are the trade-offs between production, purchase cost and nutrition?	Synergies & trade-offs	40
45	How do climate-related shocks affect household food consumption?	Drivers	45 (tie)
46	How can the private sector and civil society influence the food system?	Drivers	45
47	What can be done to facilitate marginalized migrants' and minority ethnic groups access to healthy foods for better nutrition?	Nutrition and consumer behavior	45
48	What are drivers of trust in food consumption behavior of consumers?	Nutrition and consumer behavior	45
49	What are the existing and new opportunities for linkages between international actors (e.g. Transnational Corporations, certification agencies) and local stakeholders to improve diets?	Synergies & trade-offs	45
50	What are the impacts of non-tariff technical barriers/standards/certifications on the local food market for local production and consumption? What policies regulate this?	Synergies & trade-offs	45

Priority	Research Question	Domain	Priority (By Vote)
51	How do climate coping strategies affect the food system?	Drivers	51 (tie)
52	What are the potential and impacts of some climate-smart interventions in the food system towards healthier diets?	Drivers	51
53	How do new trade agreements and FDI influence the food system?	Drivers	51
54	How is international migration driving the food systems in Vietnam?	Drivers	51

CHAPTER 3

Interactions between Food Environment and Consumption

Evidence along a rural-urban transect in Viet Nam

Abstract

There is limited evidence on food environment in low and middle-income countries (LMICs) and the application of food environment frameworks and metrics in such settings. Our study examines how food environment varies across an urban - peri-urban - rural gradient from three sites in North Viet Nam, and its relationship with child undernutrition status and household consumption of processed food. We present a picture of the food environment in a typical emerging economy with specific features such as non-market food sources and dominance of the informal retail sector. We combined quantitative data (static geospatial data at neighborhood level and household survey) and qualitative data (in-depth interviews with shoppers). We found that across the three study sites, traditional open and street markets remain the most important outlets for respondents. Peri-urban and rural areas on average had higher consumption of ultra-processed foods than in urban area. The low price levels of processed foods and the presence of processed foods even among the traditional convenience stores, those in closest proximity to the rural households, offer potential explanations of this result. Low retail diversity and household's dependence on own production have important implications for the high prevalence of child undernutrition in rural areas. Our findings add to the current discussion on the critical role of the food environment on nutrition, such as the potential link between economic marginalization and access to food, and the role of food supply channels in consumption of processed foods.

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3.1. Introduction

Countries across the world are still facing immense challenges in ensuring food and nutrition security, despite substantial progress in reducing hunger and undernutrition in the past decades, (FAO et al., 2019). To fight different forms of malnutrition, the central role of the food environment has been highlighted in several recent international reports (FAO, 2016; HLPE, 2017; FAO et al., 2019). The food environment is defined as the physical, economic, political and socio-cultural interface where people interact with the wider food system to acquire, prepare and consume foods (FAO, 2016; HLPE, 2017; Turner et al., 2018). The United Nations Decade of Action on Nutrition 2016–2025 has put a "safe and supportive environments for nutrition at all ages" as one key action area, and member States have been called to scale up research on the food environment (United Nations General Assembly, 2016).

Food environment research has gained momentum in recent years within high-income countries (HICs) in response to the high prevalence of overweight, obesity, and non-communicable diseases (NCDs) (Caspi et al., 2012; Gamba et al., 2015; Lytle & Sokol, 2017). As low and middle income countries (LMICs) are fighting multiple burdens of malnutrition, characterized by the coexistence of undernutrition along with overweight and obesity (Popkin et al., 2012; Popkin & Hawkes, 2016), the food environment is gaining policy attention in such contexts (Global Panel on Agriculture and Food Systems for Nutrition, 2016). Nevertheless, the number of studies on food environment in LMICs is still limited compared with that for high income countries. Even though the number of publications on the food environment in LMICs is increasing, they predominantly feature upper-middle-income countries and outcomes related to overweight and obesity (Turner et al., 2019).

Viet Nam, whose fast growth over the past 30 years has raised the country status from one of the poorest nations into a lower middle-income country, demonstrates the nutrition transition story. Following the *doi moi* reforms in 1990s, the decline in consumption of mainly starchy staples and increases in consumption of meat, fish and dairy products helped to lower yet not eliminate the prevalence of undernutrition: The prevalence of child underweight declined from 31.9% in 2001 to 17.5% in 2010, stunting from 43.3 % in 2000 to 29.3 % in 2010 (Le Nguyen et al., 2013). Meanwhile, data from Viet Nam started showing unhealthy food consumption patterns such as high consumption of ultra-processed foods (including instant noodles) and sweetened non-alcoholic beverages (Nguyen & Hoang, 2018). These nationwide statistics,

however, mask sub-group differences. Notably, there are large differences between rural and urban areas. While some urban provinces have virtually eliminated undernutrition, underweight and stunting remain a problem in rural areas, especially among ethnic minority communities (Vietnam National Institute of Nutrition et al., 2014). Pronounced differences in food consumption between rural and urban residents have also been observed: for example, urban residents spent less on rice and more on livestock products (World Bank, 2016). Research on the food environment can play an important role in explaining such differences and in drawing relevant recommendations. Common with several LMICs, Vietnam's food environment across the country displays the features of traditional and mixed food systems, where the co-existence of both formal and informal markets is typical (HLPE, 2017).

The objective of this study is to examine how food environment varies across an urban - peri-urban - rural gradient from three sites in North Viet Nam, and its relationship with consumption and nutrition outcomes. In examining food environment, we focused on food availability. We were motivated by the challenge of covering diverse range of food sources that exist in LMICs, such as the co-existence of formal and informal food markets, as well as non-market-based food sources like own production (Turner et al., 2018). We also looked at how food availability is linked to the personal food environment dimensions, namely accessibility, affordability and desirability. Personal food environment domains have received less attention in the literature (Turner et al., 2018). To identify potential food environment factors that play a key role in consumption and nutrition outcomes, we focused on two main outcome variables: under-5 child undernutrition status, and household consumption of processed food[6]. The former fills a global research gap in food environment research where there is an overrepresentation of overweight and obesity (Turner et al., 2020; Constantinides et al., 2021). The latter joins the growing pool of research on over-nutrition and fills a gap in healthy consumption research in Viet Nam. Our study is among the first to report processed food consumption in Viet Nam, due to the lack of a database for nutritional compositions of processed food and a dedicated section on processed food in most surveys.

[6] Processed foods include foods extracted and purified from unprocessed or minimally processed foods in order to produce culinary and/or food industry ingredients. The processes applied here are both physical and chemical processes that radically change the nature of the original foods, such as pressure, milling, refining, hydrogenation and hydrolysis, and use of enzymes and additives (Monteiro et al., 2010).

This study contributes to the nascent body of food environment research in LMICs in several ways. First, by looking at the food environment across an urban - peri-urban - rural gradient (using data from three different sites in North Viet Nam) our study provides detailed information about the food environment in an emerging economy in transition. Second, by employing a mixed methods approach that combines static geospatial data at neighborhood level and observational data (household survey and stakeholder qualitative in-depth interviews), we were able to look at household level consumption and explore its relationship with various food environment domains. Third, we cover the elements and typologies characteristic of food environment in LMICs such as non-market food sources (own production and food transfers) and dominance of the informal retail sector, providing evidence that can capture the food source typologies within LMICs environment.

The rest of the chapter is structured as follows. Section 3.2 provides a literature review of food environment research in LMICs, starting with a summary of food environment frameworks in the context of LMICs. Section 3.3 presents the methodology of the study. Section 3.4 presents the key results, which address the three research questions:

- How does the external food environment dimension, notably the availability of various types of retail outlets, the role of nonfood sources, and relative prices, vary across the urban-peri-urban-rural transect?
- How is availability linked to the personal food environment dimensions of accessibility, affordability and desirability of food vendors?
- Can differences in availability, accessibility, and affordability of food help explain the consumption of processed food and child malnutrition?

Section 5 discusses and concludes.

3.2. Literature Review

Food environment conceptual framework

The food environment is part of a food system (see for example Food and Agriculture Organization of the United Nations, 2016; Herforth & Ahmed, 2015; Swinburn et al., 2013). In food system frameworks, the food environment entails the spaces where food acquisition occurs, and the series of opportunities and constraints that influence people's food acquisition

and consumption. The dimensions of the food environment have different articulations in each framework. For example, the Nutrition Environment Measures Study (NEMS) proposed by Glanz et al. (2007) took into account a local neighborhood scale, termed the 'community food environment', and an in-store scale, referred to as the 'consumer food environment'. The popular "availability, affordability, convenience and desirability" typology proposed initially by Herforth and Ahmed (2015) was later adopted into key publications by the Global Panel on Agriculture and Food Systems for Nutrition (2016) and the Food and Agriculture Organization of the United Nations (2016). For this paper, we use the recently consolidated framework proposed by Turner et al (2018) (Figure 6). It inherited several key concepts from the framework by Herforth and Ahmed (2015) and supplements it with characteristics of the food environment in LMICs. This framework divides the food environment into external and personal domains. The key external dimension of "availability" also entails food sources important for LMICs such as home-grown foods, local community exchanges and informal vendors. The personal domain includes a set of individual level dimensions, including food accessibility, affordability, convenience and desirability. People's food acquisition and consumption are shaped by the interactions between these domains and dimensions.

This framework discussed the interrelation between availability and accessibility. Availability refers to whether a vendor or product is present or not within a given context and precedes accessibility, which includes individual spaces such as distance, time, space and place, daily mobility, and modes of transport. However, the framework did not discuss the interrelation between availability and other personal food environment dimensions such as affordability and desirability. In the result section 4.2, we report some evidence illustrating these relationships[7].

[7] We do not look at convenience separately, because this concept is usually conflated with accessibility in the literature. Herforth and Ahmed (2015) suggests that convenience "can be measured as the proximity of food outlets to homes and amounts and different types of food stores and restaurants in an area (density and variety)". Even in studies categorized by Turner et al. (2018), "convenience" is used loosely. For example, in Fuster et al. (2013), convenience was referred to as "geography" or embedded in "convenience food". Although convenience can be measured in terms of preparation time of various kinds of foods, metrics of food preparation time within the food environment literature were not available (Herforth & Ahmed, 2015).

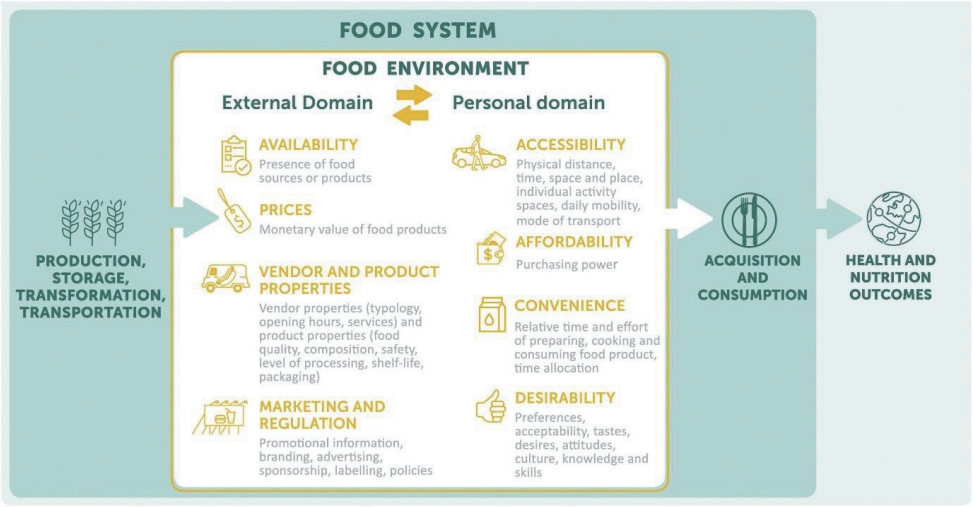


Figure 6. *Food Environment Conceptual Framework (Turner et al., 2018: Fig 2)*

Food environment research in LMICs

Lessons and conclusions from the literature have so far shed light on the role of a number of food environment dimensions in LMICs. In this section, we reviewed the findings related to our focus on food availability and personal food environment dimensions, namely accessibility, affordability and desirability.

Regarding food availability, the food environment in LMICs is usually characterized by a wide variety of food outlets, with small-and medium-sized market-based vendors dominating across a number of settings. While formalization and supermarketization have been taking place in LMICs, they have yet to take over the role of the small and medium sized and informal sector in providing food (Reardon & Hopkins, 2006; S. C. O. Wertheim-Heck et al., 2015). For examples, in a study that covered 12 cities in China, large-sized stores only accounted for 2% of all food stores, with small/medium-sized markets and specialty retailer supplying the largest share of fresh/unfrozen fruits and vegetables (Liao et al., 2016). In Thailand, small/medium-sized market-based vendors as well as traditional markets are popular and mainly serve fruit and vegetables while retail format, including supermarkets, supply modern foods such as packed and processed foods and snacks (Kelly et al., 2014; Banwell et al., 2016). Despite the importance of the small-scale outlets in LMICs, geo-coded datasets that cover the outlet diversity of the informal sector are limited (Turner et al, 2018). With extended typologies, our

study attempts to cover these smaller vendors to reflect the availability dimension of the local food environment.

An important component of food availability in LMICs is non-market sources, which include own production, wild food harvesting, and transfers, including gifts (Turner et al. 2018). In their study that covered a 15-year time span in a rural community in Mexico, Chaudhari et al. (2013) found that despite increasing presence and use of retail stores for food, subsistence activities remained significant for the local population. In a former hunter-gatherer community in Namibia, the bush and government were considered the most important food sources (Heim, 2019). Even in urban setting, non-market-based food sources may also be important, for example in the form of urban agriculture (FAO, 2014). In this paper, we have combined household consumption and expenditure data with neighborhood environment characteristics to shed light on the role of non-market sources.

Availability should also be studied in relation to the accessibility dimension. Distance to food outlets is the first commonly used variable for accessibility. Using a large dataset of 9 provinces in China, Liu et al. (2014) found that the proximity of local wet markets in China was generally perceived to be positively associated with household dietary diversity, and a large positive caloric/fat intake effect on children from households of lower income. However, this finding was not observed in a more specific study in urban Nanjing, where the authors found no correlations between geographical proximity to supermarkets and wet markets and household dietary diversity (Zhong et al., 2018). In a study in Brazil, the distance to supermarkets and fresh produce markets had positive impacts on fruit and vegetable consumption, but not on sugar sweetened beverages consumption (Duran et al. 2016). Modes of transport is the second commonly used variable for accessibility. No clear pattern emerges from the literature. Liu et al. (2014) indicated the positive association between public transport with dietary diversity, but the negative relationship between costs of access to food with dietary diversity in rural China. Instead of spending money to buy food, rural consumers had to spend a certain amount of money to travel to the nearest supermarkets to buy food. A more recent qualitative study in peri-urban India mentioned the reliance on bus or walking to markets in the town to purchase vegetables, although accessibility was not considered the most important drivers of fruit and vegetable acquisition and consumption in the setting (Surendran et al., 2020). In our

study, we collected both aforementioned measures: distance to the closet outlet (quantitative measurement) and mode of transport (qualitative observation).

Affordability was the personal food environment dimension with the least coverage in LMICs food environment research (Turner et al., 2020). Most papers have drawn insights from qualitative interviews to understand how the individual purchasing power interact with prices to determine food purchase and consumption. For example, in a study in rural Mexico, participants expressed concern about the affordability of foodstuffs such as meat, which was usually consumed only once a week, even when women included meat as part of their ideal meals and a butcher was available in the area (Kimoto et al., 2014). Another study in Cape Town, South Africa looked at affordability and the selection of informal sector (Spaza shops) versus formal sector (supermarkets). The urban poor was found to utilize the Spaza shops, which offers lower prices and smaller quantities, to compensate for insufficient income and fully participate in the formal economy. While supermarkets were often utilized for big bulk spending at the end of the month (for salaried workers or pension and social grant recipients), Spaza shops provided smaller basic staples on a daily or weekly basis and for those without a consistent income stream (Peyton et al., 2015). Davies et al. (2017) measured affordability for a community in the Amazonian dessert by the price of a healthy food basket. This food basket was significantly cheaper in higher service level shops than in the most basic ones, and relative affordability of this food basket is much lower in low-income neighborhoods. In this paper, we combined results from qualitative household interviews with household's income data across the three sites to explore how the varied affordability levels had different implications for households in three areas, in relation to availability of food products.

The desirability of food vendors and products is shaped by people's individual preferences, acceptability, tastes, desires, attitudes, culture, knowledge and skills. In the literature, there has been more attention paid to the desirability of food products. Maxfield et al. (2016) found that non-traditional and non-local foods were considered prestigious by Indian adolescents. Hunter-Adams (2017) explored how migrants in Cape Town, South Africa found traditional food from home to be more desirable than counterparts in the new city. Fuster et al. (2013) discussed how local notions of healthy eating compared with the national Salvadoran dietary guidelines recommendations. For this study, we focus on the desirability of food vendors by

exploring households' preferences for certain types of food vendors, both informal and formal ones.

Another important line of research investigates the relationship between food environment factors and nutritional outcomes. Several studies use the consumption and nutritional status of children as an outcome. In a study in Kunming, China, adolescents who lived in the areas with higher numbers of fast food restaurants and convenience stores consumed more sold packaged and processed food and beverages, but few fresh fruits and vegetables, therefore suffered higher percentage of overweight (Hua et al. 2014). Another study on children aged 6-17 years in China found that boys living in the 2nd quartile of the proximity to the nearest grocery store had higher BMI than those in the 1st quartile as they consume more fast foods (Zhang et al., 2016). A significant positive relationship was found between convenience stores and BMI in Ghana as hypothesized (Dake et al., 2016). The evidence seems to pivot towards the hypothesis that modern retail environment has a negative impact on youngsters' unhealthy consumption and over nutrition status. Nevertheless, the absence of attention to child undernutrition is a striking omission within the literature (Turner, 2020). Some suggestive evidence, however, is available on how food environment can contribute towards undernutrition. For example, in their research on the urban food environment in China, Wang and Shi (2012) showed that density of wet markets within five kilometers positively influences 6-18-year children's nutritional intake (daily caloric intake, daily carbohydrate intake, daily protein intake, and daily fat intake). Our study, with data on child nutritional status, cover both under and over-nutrition issues to address the research gap in food environment and undernutrition research. We do not attempt to establish causality, but rather identify the key food environment characteristics that deserve further investigation.

An important finding in the literature is the food environment disparities along an urban - rural transect. As these studies require rich transect data, the number of published studies on food environment that go beyond one setting is limited, however. Some studies include Liao (2016) who observed that high-income cities in China tended to have lower densities of food stores and food service places, and medium urbanized cites tended to have the highest densities of food stores and food service places. High-income versus low-income, high urbanized versus low urbanized areas had significantly more large-sized supermarkets and fewer small/medium-sized markets (Liao 2016). A similar pattern was observed in Uganda, where formal food retail

outlets had greater presence in the urban site, while informal food retail outlets were more prevalent in the rural site (Spires et al., 2020). In the same study, the authors also found that more of the food items were made available by retail outlets in the urban setting when compared to the rural setting in both Uganda and South Africa. Besides descriptive results, there is also correlational evidence that the importance of food outlet availability in citizens' diets varies across the rural-urban transect. For example, Wang et al. (2017) found that the number of food outlets correlates with diverse diets in rural areas but not in urban area. Our study seeks to add to this evidence pool by comparing and contrasting the situation in three areas: urban, peri-urban and rural. We expect to see a similar pattern observed in literature: the decrease in market food source availability across the transect. Besides, dependence on non-market food sources is also expected to vary among the sites, with the rural area depends the most on non-market foods. As single-site studies have suggested, accessibility may pose the greatest problems for rural areas.

Methods to study food environments

Multiple tools that complement each other are required to comprehensively capture the various dimensions of the food environment (Herforth and Ahmed, 2015). However, in practice, different methods have been used independently to study food environment. In terms of quantitative approaches, the combination of methods in LMICs has been limited, with less than a fifth of reviewed papers using more than a single approach (Turner et al., 2020). Among those using multiple approaches, Davies et al. (2017) used geographic information system (GIS) data to identify household locations with insufficient access to healthy food, and data collected from food shops, which indicated the widespread insufficient access to healthy food in smaller towns in the Brazil Amazon. Zhang et al. (2016) combined GIS data on distance to food establishments and anthropometric measurement data from health surveys among 348 children in China. They found that higher BMI was inversely related with proximity to a Chinese style restaurant, and positively with proximity to a free market. Anggraini et al. (2016) collected data on frequencies of purchase from different food stores and women's food consumption and observed significant associations between frequencies of buying food from certain stores with consumption of specific foods.

Though limited, papers that use mixed methods, combining both quantitative and qualitative approaches are on the rise. In a study on local food environments in Mexico, the authors

combined quantitative analysis of the density, proximity, food variety, quantity, quality, pricing and promotion of food outlet types, with in-depth qualitative research completed with families in the communities (Bridle-Fitzpatrick, 2015). The results showed that excessive access and exposure to unhealthy foods and drinks - "food swamps" was of greater concern for obesity-prevention policy. Carried out in South Delhi, the study of Finzer et al. (2013) examined relationships between consumer characteristics and fruit and vegetables purchasing by integrating a structured questionnaire and in-depth interviews. Affordability, not accessibility, was found to be especially important to increase the consumption of fruits and vegetables from street vendors and markets. Using mixed method research in Mexico combining household survey, focus group discussion and participant-observation, Chaudhari et al. (2013) concluded that the increasing presence of retail food stores lead to a growing selection of processed foods amongst consumers and refrigeration enabled higher availability of healthy foods (milk, fruit and vegetables) in the localities.

Our study learned from the best practices from these studies and adopted a mixed method research design framework, which is detailed in section 3.3.

3.3. Methodology

Research design

Our study used a mixed methods design. We first obtained quantitative data, which was a combination of static geospatial data and observational survey data. We then continued with qualitative data collection. The data was analyzed independently using a common conceptual framework and research questions. The analysis results were integrated and brought together in the overall interpretation. Table 2 summarizes the data collection methods for the study.

***Table 2**. Data collection methods*

Data collection method	Collected variables	Nature of data
Household questionnaire	Consumer knowledge, attitude and practices of food consumption	Quantitative/Observational
Neighborhood transect walk	GPS location of outlets Types of outlets Types of food groups on sale	Quantitative/Geospatial
Focus group discussions and in-depth interviews	Consumers' perception of food environment's key domains	Qualitative/Observational

Although the food environment can be studied at different scales, our available data makes it the most appropriate to study the food environment at the community and household scale. To characterize the food environment in the three sites, we used descriptive statistics to reflect key features of household (personal) and neighborhood food environments (external). Whenever possible, comparative statistics are provided to illustrate the urban-rural divergence. The qualitative interviewees were analyzed using deductive thematic approach, based on the main dimensions of the food environment.

Data

Our study uses data collected from 30 villages[8] in the three districts of Cau Giay (urban site), Dong Anh (peri-urban site) and Moc Chau (rural site). The urban and peri-urban sites belong to the capital Hanoi, while the rural site is located in the mountainous province of Son La[9]. The sites were pre-selected for in-depth study at part of the CGIAR program Agriculture for Nutrition and Health (A4NH)(de Haan et al., 2017)[10]. In each of the sites, 10 villages[11] were randomly selected for in-depth study. Our data addresses some limitations of previous mixed methods studies. For example, a study that investigated the relationship between physical proximity and obesity risk admittedly suffered from a non-representative sample due to the phone survey method and the self-reported outcome variable (obesity) (Drewnowski et al., 2012). In our study, questionnaire data was collected via personal interviews and child anthropometric measurements were directly taken in the field. In combining quantitative and qualitative data, we also improved upon the research by Bridle-Fitzpatrick et al. (2015), which was conducted within a single city and a small sample of purposively selected socioeconomic status communities.

Quantitative data

For the household surveys, 25 households from each village were randomly selected from the household list provided by village leaders. The person who was mainly responsible for

[8] In urban Cau Giay, the equivalent unit of village is ward. For simplicity, we referred to both wards and villages as "villages" in the paper.
[9] The classification of urban-peri-urban-rural follows the official administrative classification, familiar throughout Vietnam.
[10] https://blog.ciat.cgiar.org/partial-food-systems-baseline-assessment-at-the-vietnam-benchmark-sites/
[11] The 10 villages were a random subset of the 30 villages that were selected following a probability proportional to size (PPS) procedure. These 30 villages were included in an overarching study that covers more surveys and questionnaires.

household food purchase and/or preparation was the main respondent of the survey. Besides socio-demographic data, the survey covered food consumption, food shopping behavior, motives for food choice, nutrition knowledge and eating habits. During data collection, the GPS locations of the households were collected as means to control data quality and enumerators' diligence. We later used this GPS data points to calculate the indicator for accessibility dimension.

To explore the external environment of the 30 research neighborhoods, geospatial mapping of different food outlets was conducted through a transect walk in the 'food ecosystem' (rural to urban) to map food outlets. Where formal maps and data do not exist, transect walks are considered excellent tools for creating a record of a community's environments (Neve et al., 2021). In this walk, the researcher walked (or drove around in rural areas to cover the large distances) with a local guide within the administrative border of the 30 sampled villages, locating all the food retailers in the area and completing a database. The retailers were categorized into twelve groups; the definitions are listed in Appendix 1. The definitions are derived from industry standards and previous research on food sources (The University of Adelaide, 2018). The resulting database[12] includes all food retail stores and restaurants as well as direct producer-to-consumer marketing venues such as farmers' markets and farm stands. To determine in-store food group availability, we walked through the outlet when this was allowed. When a store was closed, we consulted the local guide to complete the information. The eight food groups for which data was noted were: 1) grains, roots, and tubers, 2) flesh foods, 3) dairy and/or their alternatives, 4) eggs, tofu, nuts and seeds and legumes/beans, 5) oils, 6) fruits, 7) vegetables, and 8) other processed foods like chips, candy, and soda beverages.

To assess the issue of malnutrition, we calculated weight-for-height, height-for-age (length-for-age) and weight-for-age were interpreted by using the Z-score classification system. WHZs, HAZs and WAZs were calculated using the 2006 WHO child growth standards. Prevalence of stunting, underweight, wasting and overweight of children under five were defined according to WHO classifications (2014).

[12] https://cal.maps.arcgis.com/apps/MapJournal/index.html?appid=75b4657a6a0243bc963fe5e0e3e48d92

Qualitative data

10-to-35-minute semi-structured interviews were conducted with primary food shoppers in the three sites to gain further insight into the perceptions of the consumer's food environment. We applied a mixed sampling approach. In rural and peri-urban site, the participants were randomly selected from the previous participant list of the quantitative component. In urban site, we selected other respondents outside of the original quantitative sample, as most participants of the earlier quantitative research would work during the time of the interview or were mostly busy with preparations for the upcoming Lunar New Year. The total sample size was 56, comprising of 20 rural, 20 peri-urban and 16 urban respondents.

The interviewees responded to questions about multiple aspects of the food environment in a semi-structured interview. The interview guide covered five main issues: 1) availability, 2) accessibility, 3) affordability, 4) standards of products, and 5) resident's needs concerning food outlets in their defined neighborhood.

3.4. Results

The external food environment across the urban - peri-urban - rural transect

Market-based retail outlets

Our data provides three measures of availability for market-based food sources: the presence of different types of food outlets; the presence of different types of food groups; and density of food outlets in the neighborhood (the number of food outlets per 1000 inhabitants). While the urban and peri-urban areas are now familiar with the presence of modernized food outlets, the rural area is still dominated by the traditional outlets. In Table 3, food outlets are divided into three sub-groups, including traditional food selling outlets, modern food shops, and food service shops (cafés, diners and restaurants), in order to capture the modernization of the three study sites. In the urban and peri-urban areas surveyed, food outlets appear more diverse than those in the rural area (11 and 12 types, compared to 5 types, respectively). Traditional food selling outlets (convenience stores such as traditional grocery stores for food or drink) remain the most important outlets/sub-category, accounting for the highest percentage of food outlets in the rural area (93.9 percent) and quite high in the peri-urban (50.3 percent) and urban area (45.5 percent). Food service shops are recognized to be most common in the urban area (accounting for 49.2 percent of all food outlets in the area). This

sub-group's relative presence compared to other type of outlets is lower in the peri-urban (41.0 percent), and lowest in the rural area (6.1 percent). Modern food shops are unavailable in the rural area.

***Table 3**. Count and density of food outlets, by outlet type and area*

Food destination	Rural			Peri-urban			Urban		
	No. of food outlets	Density (per 1,000 pers)	%	No. of food outlets	Density (per 1,000 pers)	%	No. of food outlets	Density (per 1,000 pers)	%
Traditional food selling outlets	**46**	**9.7**	**93.9**	**145**	**3.6**	**50.3**	**120**	**10.3**	**45.5**
Convenience stores (traditional grocery stores for food or drink)	0	0	0	23	0.6	8.0	8	0.7	3.0
Convenience stores (traditional independent small grocery stores)	43	9.1	87.8	77	1.9	26.7	49	4.2	18.6
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	2	0.4	4.1	37	0.9	12.8	60	5.1	22.7
Informal street markets (mobile vendors)	0	0	0	2	0.1	0.7	3	0.3	1.1
Formal open markets (wet markets)	1	0.2	2.0	6	0.2	2.1	0	0	0
Modern food shops	0	0	0	**25**	**0.6**	**8.7**	**14**	**1.2**	**5.3**
Convenience stores (new style)	0	0	0	4	0.1	1.4	7	0.6	2.7
Bakery	0	0	0	10	0.3	3.5	6	0.5	2.3
Specialized shops (fruit & vegetable shops)	0	0	0	11	0.3	3.8	1	0.1	0.4
Food service shops	**3**	**0.6**	**6.1**	**118**	**3.0**	**41.0**	**130**	**11.1**	**49.2**
Street bars	1	0.2	2.0	30	0.8	10.4	2	0.2	0.8
Restaurants and dinners	0	0	0	11	0.3	3.8	13	1.1	4.9
Casual dining restaurants	2	0.4	4.1	64	1.6	22.2	99	8.4	37.5
Cafés	0	0	0	13	0.3	4.5	16	1.4	6.1
Total	**49**	**10.3**	**100**	**288**	**7.2**	**100**	**264**	**22.4**	**100**

Regarding density measure, with 22 food destinations available per thousand inhabitants, the urban food environment exhibits the highest food outlet density. The rural area offered ten food destinations available per thousand inhabitants, characterized by a limited variety in which traditional independent small grocery stores make up the major share. The peri-urban area had seven food destinations available per thousand inhabitants, a surprisingly low number when compared to the number of food destinations available in the urban and rural areas.

Regarding the presence of different types of food groups, Appendix tables 2.1-2.8 show the percentage of each defined food group available per outlet type across the three areas. Grains, roots and tubers are more common in traditional grocery stores, formal open markets, bakeries, and new style convenience stores in urban and peri-urban areas. The low share of outlets selling grains, roots and tubers in the rural area (32.6 percent) is likely explained by a high dependence on household production. Traditional independent small grocery stores[13] in the rural area were the main provider of fresh produce. In the urban area, all the new style convenience stores carried fresh produce such as vegetables, fruits, and flesh foods. Most notably, unhealthy foods like chips, candy, and sugared beverages appeared in many convenience stores, both traditional and new-style, across the three areas.

Non-market food sources

We attempted to quantify the role of non-market food sources, by using the difference between the reported monetary expenditure and the calculated value of food consumption as a proxy for self-subsistence (Table 4). On average, only 60% of the food costs by the rural household is included in the reported food expenditure. The rest may stem from their own production or non-monetary transactions such as from friends and family members. For peri-urban households, this figure is about 77%, and for urban households, it is 100%. The differences may also reflect some measurement errors: the value of food consumption, when broken into smaller components, was likely to be more accurate than the reported food expenditure. Under the assumption that the measurement errors do not vary across the three sites, the differences between the reported food expenditure and value of food consumptions

[13] The other types of outlets were almost non-existent in the rural area (see Table 1).

were still statistically significant across the three sites. We saw a gradual decrease in the role of non-market food sources across the rural-urban gradient.

***Table 4**. Weekly household income and food expenditure (in thousand VNDs), by area*

Site	Value of food consumption		Reported food expenditure		% reported expenditure in the total value
	Mean	SD	Mean	SD	
Rural (N = 238)	1356	753	515	428	40.0
Peri-urban (N = 233)	1604	819	1052	576	76.7
Urban (N = 246)	1839	1048	1664	1184	108

In Table 5, we reported the average proportion of consumption that comes from household's own production for some of the main foods. Apparently, rural households derive a majority of their own consumption from own production. Peri-urban households also depend on own production for their consumption, albeit to a lesser extent. Meanwhile, urban households seem to depend almost entirely on market-based food sources for their food.

***Table 5**. Average percentage of consumption from own production, by type of food and area*

Food item	Rural		Peri-urban		Urban	
	%	N	%	N	%	N
Rice	58.4	189	29.7	183	1.85	54
Sticky rice	64.3	97	10.7	56	0	18
Dark green leafy vegetables	84.4	205	37.3	190	2.04	56
Other vegetables	62.4	181	10.9	151	0	51
Fruits	64.1	191	6.7	178	0	51
Unprocessed meat	37.9	226	3.16	171	0.71	49
Eggs	31.4	179	9.14	181	1.96	51

Note: The number of observations changes by food item as it indicates the number of households that consume the respective item.

Relative prices of processed foods

Unsurprisingly, prices of processed foods varied across the transect. We compared the relative prices of processed foods across three areas, using the rice price as reference in Table 6. These prices were collected from the household surveys where the respondents reported the prices they paid for food items. Rural households paid significantly less than their urban and peri-urban counterparts for several foods such as biscuits, cakes and ice-cream. If price is an indication of the quality of food that households consume, this suggests that rural area residents usually buy food of poorer quality[14]. For example, while in the urban area ice creams consumed are usually packaged and of brand names, the "ice-creams" consumed in rural areas are mostly home made with high water and ice content that help keep the prices low. Meanwhile, some processed foods such as breads and sugared milk beverages were relatively cheaper in urban areas than in rural and peri-urban areas, possibly thanks to higher supply and lower transport costs. There were no significant differences among relative price levels of other food items.

***Table 6**. Price of processed food relative to rice, by area*

Food item	Rural (N = 205)	Peri-urban (N = 228)	Urban (N = 229)
Breads (bakery)	3.04[a]	2.88[a]	1.94[b]
	(2.89)	(1.70)	(1.21)
Biscuits (cookies)	9.47[a]	8.76[a]	14.59[b]
	(4.85)	(4.79)	(7.35)
Cakes and pastries	9.35[a]	11.76[a,b]	13.38[b]
	(5.01)	(7.24)	(5.22)
Sweets (Chocolate, candies, etc.)	4.34[a]	6.06[a]	5.18[a]
	(3.55)	(4.05)	(2.84)
Chips and similar snacks ("bim bim")	3.89[a]	4.12[a]	3.40[b]
	(1.27)	(0.87)	(0.62)
Soft drinks	1.55[a,b]	1.91[b]	1.35[a]

[14] Our qualitative observation ruled out the case of third-degree price discrimination

	(0.83)	(1.09)	(0.51)
Ice-cream	5.01[a]	6.44[b]	8.80[c]
	(2.32)	(3.19)	(3.26)
Sausages	5.46[a,b]	7.04[a]	5.73[b]
	(2.47)	(2.93)	(2.29)
Pressed, spiced meats	8.43[a]	7.93[a,b]	7.15[b]
	(2.92)	(3.85)	(2.58)
Salted/Cured/Smoked meats	13.98[a]	8.57[a]	10.33[a]
	(9.76)	(6.04)	(2.93)
Other processed meat(chicken nuggets, sausages, burger)	11.15[a]	5.37[b]	6.51[a,b]
	(5.33)	(2.83)	(3.52)
Canned vegetables and fruits	3.82[a]	3.22[a]	2.61[a]
	(1.01)	(2.99)	(0.87)
Instant noodles	3.82[a]	4.02[a]	3.63[a]
	(1.28)	(1.51)	(1.39)
Canned or dehydrated soups, stews and pot noodle	4.92[a]	3.11[a]	5.81[a]
	(0.86)	(1.66)	(1.13)
Sugared breakfast cereals	3.85[a,b]	6.43[a]	3.71[b]
	(0)	(2.65)	(1.79)
Sugared milk beverages	7.56[a]	7.54[a]	5.90[b]
	(1.27)	(2.33)	(1.43)
Infant formulas and other baby foods	34.99[a]	22.44[b]	29.07[a]
	(14.81)	(15.23)	(10.23)

Note: Standard deviations in parentheses. If the numbers are different in [a, b, c], the differences are statistically significant using Tukey's tests, $\alpha = 0.05$

Linkage between availability and personal food environment dimensions

Personal food environment dimensions can interact with external food environment domains to shape food acquisition and consumption (UNSCN, 2016; Turner et al., 2018). In this section, we look at how personal dimensions, such as accessibility, affordability and desirability, qualify food availability across the three areas.

Availability and accessibility

We use proximity to food destinations (the distance from one household to the closest food outlet) as one measure of accessibility. Not surprisingly, urban consumers, who are exposed to the largest diversity of food destinations, also have the most convenient access to these outlets compared to peri-urban and rural ones. Table 7 shows the average distances from a household to the closest available food destinations in the commune. For urban households, the average distances ranged from as little as 81 meters (to reach the nearest casual dining restaurant) to about 2.5 kilometers (to reach the nearest beer corner). The figures for peri-urban households ranged from 164 meters (to reach the nearest traditional independent small grocery store) to about 7 kilometers (to reach an informal street market). Meanwhile, rural study households need to cover a distance of nearly 2.5 km to reach the nearest traditional convenience store. In the urban area, there are seven types of food outlets located within a distance of less than 500 meters, including street markets and convenience stores. Six types of food outlets in the peri-urban area are located less than 2 kilometers away from households. The nearest informal street market, for example, is on average less than 300 meters away. By contrast, in rural area only traditional independent small grocery stores are located less than 2.5 kilometers away - a reasonable distance that a household can reach on a daily basis.

***Table 7**. Mean household (hh) distance value to the closest food retail outlet (meters), by area*

Food outlet	Mean hh distance from closest retail outlet, by area		
	Rural (N = 79)	Peri-urban (N = 29)	Urban (N = 103)
Traditional food selling outlets			
Convenience stores (traditional grocery stores for food or drink)	-	2,729[b]	445[a]
Convenience stores (traditional independent small grocery stores)	2,432[b]	164[a]	91[a]
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	13,896[b]	229[a]	270[a]
Informal street markets (mobile vendors)	-	7,196[b]	1,849[a]
Formal open markets (wet markets)	9,270[b]	1,178[a]	-
Modern food shops			
Convenience stores (new style)	-	3,142[b]	434[a]
Bakery	-	2,138[b]	1,355[a]
Specialized shops (fruit and vegetable shops)	-	4,084[a]	2,071[a]
Food service shops			
Street bars	16,494[c]	354[b]	2,488[a]
Restaurants and diners	-	6,113[b]	262[a]
Casual dining restaurants	8,307[b]	153[a]	81[a]
Cafés	-	485[b]	137[a]

Note: Standard deviations in parentheses. If the numbers are different in [a, b, c], the differences are statistically significant using Tukey's tests, $\alpha = 0.05$

Physical distance was not the only factor that hindered rural residents' access to food. The roads through mountainous areas were not well maintained and considered dangerous especially during the rainy season. Interviewees in rural areas, especially those living in communities with very bad or rocky roads, due to mobility disabilities and low incomes without ownership of a motorbike, claimed to have worse access to food than those with paved roads.

The rural district had two main formal open daily markets but both markets were hard to reach due to the large distance and difficulty in getting there. Meanwhile, even though the interviewees in the peri-urban and urban area were satisfied with the number of food outlets in their communes and their access to them, some mentioned that out of curiosity or for diversity in their meal, they would sometimes like to shop at outlets outside their own communes.

Availability and affordability

The varied affordability levels had different implications for households in three areas, in relation to availability of food products. For example, in the rural area, 65% (13/20) of the interviewed participants expressed that although meat is available in their neighborhood (60% of the store sold flesh products), it was too expensive to consume as much as they would like. In most communes, meat (mainly pork) costs around 100-110 thousand VNDs per kilo, while one participant indicated his willingness to pay only between 50 – 80 thousand VNDs per kilo. This is consistent with the household survey result that most households had meat as their priority to improve their diet if their income improves.

To assess the purchasing power of the households, we first used their reported income as a proxy. Figure 7 describes how income is distributed across the three sites, according to 10 intervals of income (with 1 representing the lowest income level and 10 representing the highest income level). We saw a clear gradient from urban-rural, where about a third of the surveyed urban households had a monthly income of the highest level (more than 20 million VNDs (860 USD). About the same proportion of the rural households had the lowest level of income (less than 3 million VNDs – 128 USD)[15].

[15] As the income data was collected by a scale-based question, we could not calculate the income per capita, although we did collect data on the number of household members. The number of household members in each site was similar, at 4-5 members per household.

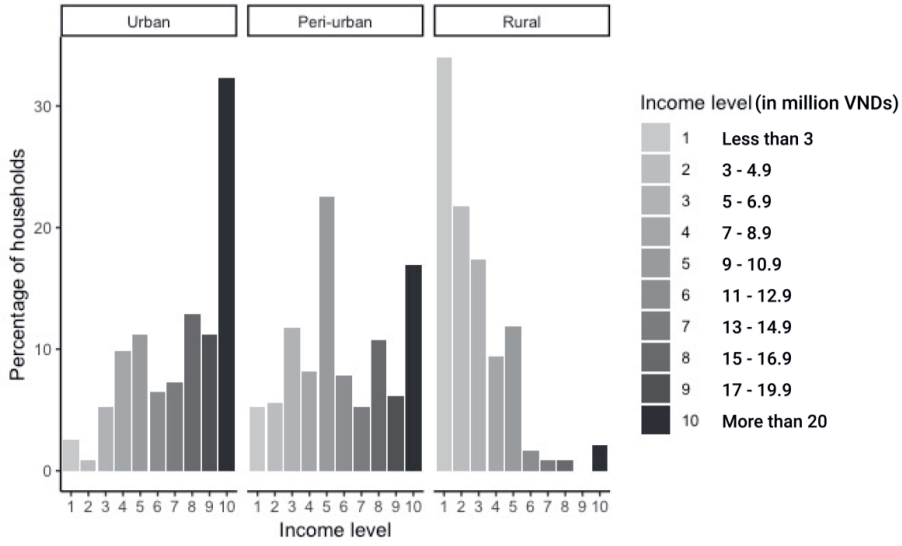


***Figure 7**. Monthly household income distribution, by area*

In peri-urban area, large differences were observed in the perception regards the cost of the food. There was a mix of people who experienced their groceries to be expensive, reasonable, and even cheap. Those indicating the food was expensive admitted that they just did not earn enough. Nevertheless, according to at least one respondent who worked for the health center:

"These people may find the food expensive, but would often grow a lot themselves, making them less depending on the market sources for food".

(Respondent 4, peri-urban, interviewed in February 2019)

This suggests the role of non-market food sources in easing the affordability issue for households.

In the urban area, a large majority (14 out of 16) of the interviewees described the price of their groceries as "reasonable" and shopped at the street markets. But the weather and seasonality were considered to play a major role in the price fluctuations. At the time of the interviews, it was almost time for the Lunar new year (Tết), and some interviewees indicated that food prices would rise as a result.

The general sentiment is the cost of food at the supermarket was pricey, especially since the quality was not perceived to be better:

"I don't like the supermarket because I bought expensive glass noodles there and the quality is not better than at the market. At home I read about the brand online and saw that it's produced in my hometown, which I know is very dirty."

(Respondent 9, urban, interviewed in January 2019)

The two remaining respondents, who both lived in the same commune, considered the price of their groceries as 'very expensive'. One of them shopped at a new style convenience store, the other at the supermarket. Nevertheless, they enjoyed the fact that prices at the convenience store and the supermarket were considered to be fixed, with little changes in fresh produce per season.

Availability and desirability of food vendors

Across the three areas, the choice of food vendors depends on various factors. Using the household survey data, we examined the stated reasons for the most frequent type of outlets used by households in each area. Most consumers in the urban district obtained the majority of food from formal open markets (more than 50% of the households) and informal street markets (31.7% of the households). The top reasons for selecting formal open markets is habit, variety and convenience. The top reasons for selecting informal street markets are similar, although availability of healthy foods and food quality were also mentioned. In the peri-urban district, most households obtained the majority of their food from informal street markets (51.7% of the households) and formal open markets (44.4% of the households). The top reasons for selecting the open markets (both formal and informal) are habit, food quality, reputation, convenience, food safety and personal contact. Households in the rural area obtained most of food from informal street markets (41.6% of the households) and traditional convenience stores (39.9% of the households). The top reasons for selecting the convenience store and informal open markets are similar with those listed by the urban and peri-urban respondents, although the availability of credit was also an important reason.

In-depth interviews with respondents revealed some additional insights. When asked about why they still prefer open markets to supermarkets, urban respondents noted the need to resist temptation offered by the range of available products at the supermarkets:

"You come for water but then you want to buy everything that is around. You want to buy chocolate and then you buy dark chocolate, white chocolate and other candy, and then you need to pay much more."

(Respondent 9, urban, interviewed in January 2019)

In the peri-urban area, sometimes, the availability of local vendors actually prompted households to go to a further location to get a better deal, as explained by a respondent:

"I don't want to go the market at this community because I want to bargain…. I am afraid of what other people think of me and think that I am cheap, therefore, I go to the market 2km away from here where people don't know me so I can bargain for a better price."

(Respondent 2, peri-urban, interviewed in February 2019)

Consumption and nutrition outcomes across the transect

In this section, we first provide statistics on processed foods and nutritional status across the transect. Afterwards, we discuss the food environment dimensions that would help explain the differences across the three sites.

Consumption of processed foods

Across the three areas, the most frequently consumed ultra-processed foods are instant noodles, sugared milk beverages, and bread. The percentage of rural consumers having instant noodles (80 percent) was significantly higher than those of urban and peri-urban households. Yet, while the majority of urban and peri-urban households consumed bread, only 29 percent of rural consumers did so during the week before the interview (Table 8).

***Table 8**. Share of households who consumed a certain food item in the past 7 days, by area*

Food groups and items	All	Rural (N = 238)	Peri-urban (N = 236)	Urban (N = 249)
Instant noodles	71.4	80.2[b]	70.3[a]	63.9[a]
Sugared milk beverages	57.5	54.2[a]	62.7[a]	55.8[a]
Breads (bakery)	53.5	29.4[c]	60.6[b]	69.9[a]
Pressed, spiced meats	48.5	33.6[b]	58.9[a]	53.0[a]
Chips and similar snacks	40.7	50.4[b]	38.1[a]	33.7[a]
Infant formulas and other baby foods	31.4	10.1[c]	36.9[b]	46.6[a]
Ice-cream	31.3	25.6[b]	33.5[ab]	34.5[a]
Soft drinks	29.5	46.6[b]	22.0[a]	20.1[a]
Cakes and pastries	28.8	20.2[b]	30.9[a]	34.9[a]
Sweets (Chocolate, candies, etc.)	27.8	34.0[b]	25.0[a]	24.5[a]
Biscuits (cookies)	24.1	16.0[b]	27.1[a]	28.9[a]
Sausages	23.6	15.5[b]	28.8[a]	26.5[a]
Other processed meat including chicken nuggets, sausages, burgers, fish sticks	7.3	1.7[c]	7.2[b]	12.8[a]
Sugared breakfast cereals	6.9	1.3[b]	7.6[a]	11.6[a]
Canned or dehydrated soups, stews and pot noodle	4.8	10.9[b]	1.3[a]	2.4[a]
Salted/Cured/Smoked meats	4.7	5.0[a]	3.0[a]	6.0[a]
Mayonnaise	4.7	0.0[b]	1.7[b]	12.0[a]
Canned vegetables and fruits	1.7	1.7[a]	0.8[a]	2.4[a]
Jams (preserves)	1.5	0.4[b]	0.4[b]	3.6[a]

Note: If the numbers are different in [a, b, c], the differences are statistically significant using Tukey's tests, $\alpha = 0.05$

Based on the weekly amount reported by households, we calculated the total weekly consumption (in kilograms) of processed food per capita of a household (Table 9). Peri-urban and rural areas on average had higher consumption of ultra-processed foods than urban area, although the differences were not statistically significant. This result is contrary to the common hypothesis that urban households consume more processed foods than their rural counterparts do, due to modernization and supermarketization. In our setting, the presence

of processed foods in the traditional outlets, which are in closest proximity to the rural households, might offer an explanation of this result.

The surveyed households also spent a considerable share of their food budget on processed food, ranging from 16% (rural area) to 22% (peri-urban area). Although the rural household consumed a higher amount of processed food (in total kilograms), processed foods took up a lower value share from lower total consumption. There could be two explanations for this: First, relative price levels of some processed foods are lower than those in urban and peri-urban area for some foods, as discussed before in 4.1.3. Second, rural households seem to eat different processed foods than their urban and peri-urban counterparts. Table 10 displays some foods where there are big gaps between the areas: Sweets were consumed much more in peri-urban and rural areas than in the urban area. Snacks, soft drinks, instant noodles, canned food were consumed much more in rural area than in other areas. Meanwhile, several modern options seemed mostly important in urban area, such as chicken wings and sweetened breakfast cereals. Appendix 3 displays the consumption amount for all processed foods.

***Table 9**. Consumption of processed food per week*

	Total consumption of processed food (in kg)				Share of processed food expenditure in total food expenditure			
Area	Mean	SD	Min	Max	Mean	SD	Min	Max
Rural (N = 238)	0.99	0.83	0	3.87	0.16	0.12	0	0.50
Peri-urban (N = 236)	0.95	0.86	0	5.83	0.22	0.15	0	0.68
Urban (N = 249)	0.81	0.78	0	8.26	0.19	0.13	0	0.69

***Table 10**. Average consumption of some processed foods per week (in kg)*

Area	Sweets	Chips and similar snacks	Soft drinks	Chicken wings, hamburgers, etc.	Instant noodles	Canned food	Breakfast cereal
Rural (N = 238)	0.159	0.255	1.01	0.009	0.659	0.048	0.071
Peri-urban (N = 236)	0.219	0.132	0.474	0.083	0.464	0.013	0.038
Urban (N = 249)	0.071	0.099	0.367	0.122	0.329	0.009	0.199

Nutritional status of children under 5 in the household

Anthropometric measures of the children under 5 were available for calculations of different nutritional status indicators: stunting, underweight and wasted[16]. Marked differences existed among the nutritional status of children under 5 years old across the three areas (Table 11). The rural area had the highest proportions of households whose children were stunted (30.4%), underweight (18.5%) and wasted (6.4%)

***Table 11**. Percentage of households whose children suffered from at least a form of malnutrition, by area*

Area	Stunted	Underweight	Wasted
Rural (N = 644)	30.4	18.5	6.4
Peri-Urban (N = 359)	11.1	5.0	3.9
Urban (N = 385)	6.8	3.4	1.8

[16] Prevalence of stunting, underweight, wasting and overweight among children under age five were defined according to WHO classifications: Stunting: a child whose length-for-age is below the –2 Z-score is stunted; below –3 Z-score is severely stunted. Underweight: a child whose weight-for-age is below the –2 Z-score is underweight; below –3 Z-score is severely underweight. Wasting: a child whose weight-for- length is below the– 2 Z-score is wasted; below –3 Z-score is severely wasted.

Causes of undernutrition in children under 5 are numerous, including poor access to food, unhealthy environments, and access to and control of resources (UNICEF, 2013; Mbuya et al., 2019). We identify some potential food environment dimensions contributing to undernutrition: First, the lack of retail diversity needs addressing. In our rural site, products such as dairy are not readily available, which can be accountable for the lower consumption of dairy products by the households: Only about half of the rural households eat dairy products in the last week, compared to about 70% of the households in the rural and peri-urban areas. In the rural area, only 36 percent of the traditional independent small grocery stores carried dairy or their alternatives, while this number was more than double as high in the peri-urban and urban area (Table 12).

***Table 12**. Food stores with dairy and/or their alternatives available (%)*

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	8.7	0.0
Convenience stores (traditional independent small grocery stores)	35.5	94.4	65.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0

Our regression (in Appendix 4) also shows that there is a negative correlation between food retail diversity in the village with the likelihood of having a stunted child in the household[17].

Second, we pay attention to rural households' dependence on own agricultural production. Agriculture can be linked to undernutrition in several ways: consumption of own production due to lack of market access; and consumption of more nutritious food from sales of agricultural produce and/or proximity to markets (market engagement) (Ruel et al., 2013). The limited market access means that the former pathway is important for households in our rural setting, but our data shows that own production of high protein foods such as meat and eggs only accounted for 30-40% of the total consumption. Although our data did not quantify the

[17] We had a dataset with significant missing data when matching datasets, so we do not include this in the main results.

production diversity of the households, our qualitative observation displayed a poor diversity of agricultural production, especially when it comes to livestock. As diversity of agricultural production correlates with the diversity of food available for consumption for many households in LMICs (Fanzo et al. 2014), the low diversity of own production may explain the prevalence of undernutrition. Besides, there is evidence in the literature (mostly for Africa, however) that the effect of market engagement on nutrition measures is even larger than agricultural diversity per se (Nandi et al., 2021). We speculate that the lack of market access and income from agricultural produce for rural households plays a role in explaining child undernutrition.

3.5. Discussion and conclusions

This paper investigates the food environment in Viet Nam, using multidisciplinary data from 3 study sites along the rural - peri-urban - urban transect. We found significant differences in food availability. The urban area exhibits the highest food outlet density and variety of outlets, while the rural food environment is characterized by a limited variety in which traditional independent small grocery stores make up the major share. Urban and peri-urban households enjoy a closer proximity to food service shops than rural households. In the rural area, it is not surprising to see that food service shops are not close by, as households mostly eat at home, even consuming their own food, and eating out is usually associated with higher income. Overall, this finding is therefore in line with other recent studies that highlight contextual differences of food environments by taking snapshots of urban and rural food environments (Liao et al., 2016; Wu et al., 2017; Spires et al., 2020).

To explore the linkage between availability, an external food environment dimension, and personal dimensions, we characterized households' accessibility, affordability and desirability of food vendors. Households in rural areas have much more limited access to food stores and food selection due to physical and transportation constraints. The varied affordability levels had different implications for households in the three areas, in relation to availability of food products. Households in rural areas had financial constraints to purchase more expensive products such as meat, despite availability. In peri-urban area, home grown products helped to mitigate the dependence on markets. In urban area, high availability of food outlets translates into households' easy access to affordable products. Across the three sites, preference for selection of food destinations depends on personal factors such as habit,

convenience, relationship and sometimes the need to resist temptation of a broad selection of food. Traditional open and street markets remain the most important outlets for respondents across the three study sites, a finding consistent across a number of LMICs settings (Matthew Kelly et al., 2014; Peyton et al., 2015; Liao et al., 2016).

We are among the first to quantify the amount of processed food consumed by households across an urban – peri-urban – rural transect in Viet Nam. Contrary to the common concern that urban households are the major consumers of processed foods due to modernization and supermarketization (Popkin, 2006; Wagner & Brath, 2012; World Health Organization, 2016), we found that households in peri-urban and rural areas on average had higher consumption of ultra-processed foods than in urban area. This is revealing, considering the more recent acknowledgement that the risk of double burden of malnutrition is starting to concentrate among people with low incomes in rural areas (Popkin et al., 2020) and rising rural body-mass index is the main driver of the global obesity epidemic in adults (Bixby et al., 2019). The low price levels of processed foods, as well as lower quality of processed foods in rural area may help to explain the higher consumption in rural areas. The presence of processed foods even among the traditional convenience stores, those in closest proximity to the rural households, also offers a potential explanation of this result. There is therefore a need to improve upon our results with additional data, such as market prices (instead of household-reported prices), and a segmentation of processed foods based on the quality and nutritional values.

We also attempted to identify food environment dimensions that is connected to child malnutrition. First, retail diversity is poor in areas with high prevalence of child undernutrition. There is evidence in the literature that can support this claim. In Kenya, it has been found that more retailer channels increases food variety, which leads to dietary diversity, which in turns helps lower child undernutrition (Debela et al., 2020). In Zambia, expenditure in modern retailers was positively associated with height in children, mainly through higher consumption of meat and dairy (Khonje et al., 2020). Second, rural household's level of dependence on own production demands attention. Although household's subsistence farming may have various pathways of impact on child nutrition, recent evidence in rural northern Viet Nam has shown that the direct pathway via consumption of households' own food production did not have an effect on the child's malnutrition status. Instead, the indirect pathway via consumption of diverse food due to market access and/or sales of agricultural produce was found to be

important in reducing the probability of children being stunted and underweight (Genova, 2019). The lack of market access and monetization from agricultural produce for rural households, as well as low diversity of agricultural production is limiting the opportunities for improving nutritional status of their children. As we do not have sufficient data to back these speculative ideas, further work is needed to confirm these.

The study has several data limitations. The household survey was a multi-purpose questionnaire designed for several purposes and serving different components of an overarching research program (The CGIAR Agriculture for Nutrition and Health A4NH in Viet Nam)[18]. It did not cover the broad spectrum of the food environment domains that ideally should be covered, for example marketing, which is an important component of the external food environment that can be manipulated to address healthier consumption (Downs & Demmler, 2020), or convenience, which is in need of clear indicators to distinguish it from the concept of accessibility. Besides, household GPS locations were collected mainly as means to control data quality and enumerators' diligence, rather than to collect the exact address of the household. Some enumerators had to conduct surveys in a central location in the village instead of at respondents' house. The exact location of the household was then unknown and excluded from the analysis. We therefore ended up with fewer valid data points for our estimation of proximity and for inputs into the regressions. This caused potential selection bias in Table 5 (distance from a household to the closest food retail outlet). As the food environment has been considered a predictor of child overweight in a number of settings (Hua et al., 2014; Zhang et al., 2016), our lack of statistical significance points to the need for more research with a larger sample size for a more affirmative conclusion.

Our operationalization of proximity could be improved. First, we only covered the outlets within the administrative boundary of the surveyed villages. For example, in the urban site there might be a wet market only 2 km away from the household but, being located in another administrative boundary, the wet market fell out of the scope of the transect walk. In the literature, the same approach has been used for larger administrative areas such as a city (Zhong et al., 2018). Alternative approaches that future studies can consider for smaller administrative areas include mapping outlets within walking distance from respondents' home

[18] https://a4nh.cgiar.org/vietnam/

(Duran et al., 2016; S. Wertheim-Heck et al., 2019). Second, the straight-line distances do not take into account the cost and time required to reach the food destination, consequently not representing accessibility to food destinations. This consideration is especially important for the rural site, where road conditions are poor especially in rainy seasons. The accessibility gap is therefore even greater than what the numbers convey. We used qualitative interviews to supplement for this drawback. Future studies can quantify the accessibility dimension better by bringing in temporality of the food system, e.g. accounting for seasonal changes and mobility of food vendors over time (Widener & Shannon, 2014). It has also been suggested that the framework by Turner et al (2018) should be complemented with how stable the food environment characteristics are against seasonal fluctuations and variations in climate (Constantinides et al., 2021).

Future research would benefit from more detailed analysis of processed food consumption. Due to the absence of a food composition table for processed food in Viet Nam, we could not break down the total amount into more detailed nutritional values, which would allow a more meaningful comparison among the areas. More detailed nutritional value calculations would also enable us to assess how much macronutrients and micronutrients obtained by a household is derived from processed foods, for example average dietary contribution of ultra-processed foods (expressed as a percentage of the total caloric value of the diet) (Baraldi et al., 2018).

Implications for Policies and Practices

In the last 10 years, policies in Vietnam to develop the retailing system have focused on "modernization" of food outlets, especially in urban areas and parts of peri-urban areas, by expansion of supermarkets, opening of convenience stores, upgrading of wet markets in modern style, and reduction of informal wet markets. One of the reasons for this plan is to improve food safety and diversify the retailing system. Some studies have shown the inadequacy of the reformed retail system, especially "modernization" of traditional markets, to shopping habits and purchasing power of Vietnamese (Wertheim-Heck and Raneri, 2019). Moreover, in addition to benefits of the retail diversity that the system offers, attention has been paid to the potential trade-offs between the expanded modern retail system and increased consumption of unhealthy products (like processed foods). In our study, we observed both reservations towards supermarkets for the range of unhealthy foods on offer,

and the prevalence of unhealthy food even in traditional convenience stores in the rural area. This is similar to a finding in Zambia (Khonje & Qaim, 2019) suggesting that modern retailers are not the only drivers of dietary transitions. This observation necessitates a redirection of attention to both traditional and so-called modern outlets to ensure food providers in all locations are offering healthy foods to local populations. National and international responses to undernutrition and obesity should be integrated and the focus undernutrition should be broadened, to enhance access to healthier foods in poor rural and urban communities (Bixby et al., 2019).

The research shows a high consumption of unhealthy foods (processed foods) across 3 sites and the high availability of those foods in many convenience stores, both traditional and new-style. In rural area, the low price of a number of processed foods, such as biscuits, cakes and ice-creams, and the close access to convenience shops selling these unhealthy foods is a worrying observation. This pattern has been observed in food deserts in high-income countries, where low income neighborhoods typically have access to fast food chains and outlets selling ultra-processed food. As Viet Nam has been experiencing an upward trend in consumption of processed food (Raneri et al., 2019), consumers will be unlikely to reduce purchasing those foods in the near future without extra measures. Solutions that target both consumers and retailers, such as nutrition labeling, can help to improve the transparency in communicating about the nutritional values of processed foods. Other initiatives that target unhealthy processed foods directly could be beneficial, such as taxation on sugar sweetened beverages (SSB). It has been projected that a 10% SSB tax will reduce SSB consumption by 11.4% in Vietnam, and that consumers will switch to substitutes, leading to an increase in the consumption of milk, beer, dried tea and wine by 1.7% (Luong & Vu, 2020).

Traditional markets (including formal open markets and informal street markets) are common food outlets across the rural-urban transect. In our research, a large proportion of these outlets have supplied healthy foods. Traditional markets have been recently given much attention in the development strategy with a vision to 2030 by Ministry of Industry and Trade (MOIT). However, investments to upgrade those food outlets have generally decreased as compared with previous time (Phu, 2019). The role of the central government and local authority in developing policies that aims at upgrading and developing traditional markets is very important, for example in improving the hygiene conditions and organizational capacity of such

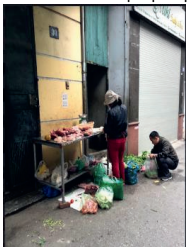
markets. In addition, campaigns for awareness raising and behavior change for consumers need to be done and improved to increase a demand and a willingness to consume safe and nutritious foods with a higher price. As we observed that most of households often buy food in shops close to home and particularly in the rural area, far distances to food outlets and poor infrastructure (especially roads) are barriers for local consumers to access nutritious foods, the government should continue to prioritize investments in improving the transportation system in poor areas to increase food access.

By 2025, Vietnam aims to reduce the childhood malnutrition and stunting rate to less than 20 percent and the obesity rate among children to less than 12 percent. Future policies such as the National Nutrition Strategy 2021-2030 can use the evidence provided in this paper to advocate for better food environment and nutrition-sensitive approach integrated into the new strategy. Increasing diversity of the retail environment in rural areas can lead to better diet diversity, which in turn may lower the prevalence of malnutrition. For example, specialized outlets that sell more nutritious foods, such as dairy products, would help rural households to improve their dietary diversity score, which is usually lower than their peri-urban and urban counterparts due to less regular consumption of dairy products. Increasing access to a larger diversity of sellers can also be achieved through transport system improvement, which serves the dual role of increasing market access to generate more household income to improve malnutrition.

In peri-urban and rural area, the extra source of agricultural products produced and rapidly supplied by local people themselves plays an important role in contribution for nutrition and health improvement. Part of this produce is sold in traditional food outlets in the areas. However, the recent reduction of agricultural areas is observed in peri-urban areas due to the urbanization process and the development of industrial zones raising concerns about food provision for inner citizens and livelihoods of peri-urban farmers (Pham et al., 2015). Therefore, local planning policy should consider the maintaining of food supply to urban areas, such as setting aside agricultural zones.

Appendices

Appendix 1. Classifications of outlets

Type of food outlet	Definition
Convenience stores (traditional grocery stores for food or drink) 	Small format store that sells only one or two ranges of products and is typically privately owned.
Convenience stores (traditional independent small grocery stores) 	Small non-chain grocery store that is typically independently owned and operated. Sells mostly processed foods and beverages of popular brands and common foodstuffs.
Informal street markets (small-scale street vendors and pop-up semi-permanent stands) 	Vendor who sells from a table, stand, cart, or stall that can be moved, but generally stays in one place during the day. Typically selling banh tieu (donuts), sausages, Banh Mi (sandwiches), broken rice cake and raw meat like pork and chicken.
Informal street markets (mobile vendors) 	Small-scale vendors operating on foot, bike/ motorbike/truck who move around during the day. Temporary sale of food in unexpected places for a limited time.

Formal open markets (wet markets) 	A market formally established by local authorities feature diverse vendors selling a variety of fresh food products often on a tiny space (1-5m^2). Vendors do not need a business license nor a store setup.
Convenience stores (new style) 	Small, modern store with 1-2 cash registers selling convenience food, typically franchised. Other characteristics: self-service, clear price tag, employees run the store.
Bakery 	Sells (and sometimes produces) flour-based foods baked in an oven such as bread, cookies, cakes, pastries, and/or pies.
Specialized shops (fruit and vegetable shops) 	Mainly sells fresh produce, e.g. fruit, vegetables, or both.
Local beer corner (“Bia hoi”) 	Place with small plastic furniture on street corners and drink home-brewed beer and many also serve fast food like grilled dried squid and fermented sausages.

Restaurants and diners 	Place where people pay to sit and eat. Meals are cooked and served on the premises and there is typically a wide range of menu options. Often with inside eating option.
Casual dining restaurants 	Typically provide table service, have a limited menu, and are affordable and fast. Typically selling: Pho, Banh mi, Rice with vegetables and meat, Bun cha, Bun Bo Nam Bo.
Cafés 	Sell coffee, tea, cakes, and sometimes sandwiches and light meals.

Appendix 2. Food group availability by outlet type and area

1. Food outlets where grains, roots, and tubers are available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	69.6	75.0
Convenience stores (traditional independent small grocery stores)	33.3	93.1	80.4
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	20.0	28.1
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7
Bakery	-	100.0	100.0

2. Food outlets with flesh foods available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	-
Convenience stores (traditional independent small grocery stores)	60.0	19.7	10.6
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	50.0	38.5
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0

3. Food outlets with fruits available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	37.5
Convenience stores (traditional independent small grocery stores)	30.0	5.5	12.7
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	25.0	64.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit and vegetable shops)	-	100.0	100.0

4. Food outlets with vegetables available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	25.0
Convenience stores (traditional independent small grocery stores)	53.4	9.6	14.9
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	35.0	36.8
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit and vegetable shops)	-	90.9	-

5. Food outlets with eggs, tofu, nuts and seeds or legumes/beans available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	4.3	37.5
Convenience stores (traditional independent small grocery stores)	45.0	51.4	29.8
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	20.0	14.1
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Specialized shops (fruit & vegetable shops)	-	72.7	-

6. Food outlets with chips, candy and soda available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	73.9	0.0
Convenience stores (traditional independent small grocery stores)	78.0	98.6	93.7
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	5.0	1.7
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7
Bakery	-	22.2	100.0

7. Food stores with dairy and/or their alternatives available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	8.7	0.0
Convenience stores (traditional independent small grocery stores)	35.5	94.4	65.9
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	100.0
Bakery	-	37.5	16.7

8. Food stores with oils available (%)

Food stores	Rural	Peri-urban	Urban
Convenience stores (traditional grocery store for food and drink)	-	0.0	12.5
Convenience stores (traditional independent small grocery stores)	37.5	73.6	74.5
Informal street markets (small-scale street vendors and pop-up semi-permanent stands)	-	5.0	3.4
Formal open markets (wet markets)	-	100.0	-
Convenience stores (new style)	-	100.0	85.7

Appendix 3. Average consumption of processed foods, food item and area

Food item	Rural	Peri-urban	Urban
Breads (bakery)	0.212[a]	0.606[b]	0.617[b]
Biscuits (cookies)	0.066[a]	0.100[a]	0.064[a]
Cakes and pastries	0.050[a]	0.134[a]	0.075[a]
Sweets (Chocolate, candies, etc.)	0.159[a]	0.219[a,b]	0.071[b]
Chips and similar snacks ("bim bim")	0.255[a]	0.132[b]	0.099[b]
Soft drinks	1.015[a]	0.474[b]	0.367[b]
Ice-cream	0.169[a]	0.193[a]	0.120[a]
Sausages	0.089[a]	0.178[a]	0.120[a]
Pressed, spiced meats	0.172[a]	0.366[b]	0.226[a]
Salted/Cured/Smoked meats	0.037[a]	0.021[a]	0.014[a]
Other processed meat(chicken nuggets, sausages, burger)	0.009[a]	0.083[a,b]	0.122[b]
Mayonnaise	0[a]	0.003[b]	0.018[b]
Canned vegetables and fruits	0.033[a]	0.024[a]	0.022[a]
Instant noodles	0.659[a]	0.464[b]	0.329[c]
Canned or dehydrated soups, stews and pot noodle	0.048[a]	0.013[a,b]	0.009[b]
Sugared breakfast cereals	0.071[a,b]	0.038[a]	0.199[b]
Sugared milk beverages	0.806[a]	1.110[b]	0.774[a]
Jams (preserves)	0.002[a]	0.005[a]	0.010[a]
Infant formulas and other baby foods	0.040[a]	0.325[b]	0.267[b]

Note: the values marked with the same letter are not significantly different at P < 0.05

Appendix 4. Effect of food environment dimensions on underweight status (logistic regression)

Average marginal effect	Probability of having an underweight child
Density of food outlets	0.00
	(0.01)
Diversity of food outlets	-0.08**
	(0.03)
Food expenditure per capita	-0.00**
	(0.00)
Household size	-0.00
	(0.01)
Knowledge score	-0.00
	(0.00)
Age of household head	-0.00
	(0.00)
Observations	108
Pseudo_R-squared	0.447

Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 4

Evaluating Methods to Increase Consumption of Healthy Foods

Evidence from a school-based field experiment in Viet Nam

Abstract

Schools are an attractive entry point to improve children's diets, as their eating habits can be shaped during childhood and the information disseminated from school can reach adults through children. We implemented a cluster-randomized trial in 12 schools in peri-urban Viet Nam to assess if two school-based interventions increased knowledge of healthy diets among children and their parents, as well as children's consumption of healthy foods. First, children were given lessons about food before school lunch and encouraged to share the lessons with their parents. Second, children were provided with healthy snacks to reinforce messages about healthy eating. We found that in the short term, the nutrition lessons raised the knowledge index score of the children by 0.35 standard deviation. After six months, this intervention did not retain its effectiveness, emphasizing the need for linkage between knowledge and practice. By itself, free access to fruit at school increased the children's daily fruit consumption by half a portion, but not at the expense of home fruit consumption. Access to healthy foods at school can therefore be an effective measure to raise children's healthy consumption. Child-parent communication was not a reliable channel for knowledge dissemination in our setting.

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4.1. Introduction

Unhealthy dietary patterns are posing global challenges, especially for low-and-middle-income countries (LMIC). Fueled by economic growth and rapid urbanization, LMIC have begun to experience a switch from mostly starchy, low fat, high fiber diets to increased consumption of processed foods higher in fats, sugar and salt. Their public health concerns are no longer limited only to undernutrition and micronutrient deficiencies but also to the high prevalence of overweight, obesity and diet-related non-communicable diseases (Popkin, 2014; Global Panel on Agriculture and Food Systems for Nutrition, 2016; Mattew Kelly, 2016). Viet Nam, economically one of the fastest growing countries in the world, illustrates the detrimental consequences of this nutrition transition. In 2018, an average Vietnamese was estimated to consume double the World Health Organization (WHO) recommendation for salt (Jensen et al., 2018) and sugar (Anh, 2018). In 2015, more than half of adult Vietnamese were found not to meet the WHO recommendation for fruit and vegetable (FAV) consumption (T. T. Nguyen & Hoang, 2018). A recent study by the National Institute of Nutrition on 5,028 students aged 7 to 17 from 75 schools in Hanoi, Ho Chi Minh City, Thai Nguyen, Nghe An and Soc Trang found that 42 percent of primary school students in urban areas were overweight or obese (Vietnam National Institute of Nutrition, 2019).

To combat the burden of unhealthy diets, many LMIC have included school-based interventions in their nutrition policies. Recent systematic reviews of policy actions to improve diets in LMIC indicated that school-based activities, such as school gardening, nutrition curriculum inclusion and school meal standard enforcements, are present in several different regions (Lachat et al., 2013; Darfour-Oduro et al., 2019). Schools are an attractive leverage point for improving diets for several reasons. First, schools are in continuous and intensive contact with children, whose eating habits are formed early in life and can still be shaped (Loewenstein et al., 2016; DeCosta et al., 2017). Second, healthy meals can have positive impacts on children's school performance (Jomaa et al., 2011). Third, schools offer strong potential to reach adults through children, particularly in environments where children are likely to be more educated than their parents (He et al., 2015; Gunawardena et al., 2016).

Two of the most commonly implemented approaches to improve diets through schools are nutrition education and increased access to healthier foods. While the former aims to change behavioral intentions, the latter strives to improve the food environment. Nutrition education

programs can positively influence the knowledge and attitude of children regarding healthy foods (Katz et al., 2011; Prelip et al., 2012; Lerner-Geva et al., 2015), while exposure and access to healthy food can induce demand and increase intake of healthier foods due to the strong relationship between familiarity and preferences (Cooke, 2007b; DeCosta et al., 2017). Providing children with free and accessible FAV has been found to positively influence children's eating behavior, even in the long term (DeCosta et al., 2017).

Although providing nutrition education and facilitating food access are popular approaches to improve children's diets, they are not foolproof, as nutrition education alone does not always lead to behavioral changes (Katz et al., 2011; Prelip et al., 2012; Mittmann et al., 2016). Reasons that nutrition education may not lead to behavior change include a lack of parental engagement, lack of a standardized implementation plan, inadequate intervention duration, and a lack of age-appropriate activities (Murimi et al., 2018). Several studies have concluded children's diets can be more effectively improved if a nutrition education curriculum and parental involvement are combined with FAV availability in schools (Van Cauwenberghe et al., 2010; Sharma et al., 2016). In these studies, however, it is not always possible to distinguish the separate effects of these two approaches because they are either combined as part of a multi-component program, or compared directly with each other (Reinaerts et al., 2008). In practice, not all schools have the capacities and resources to do both. It is therefore still useful to evaluate how the two approaches complement each other to advise practitioners on whether to pursue a holistic program in the face of constraints.

Despite the host of evidence in developed countries, there is a paucity of rigorous evaluations of school-based interventions related to healthier eating in LMIC. Experimental studies, utilizing randomization to establish causality, have typically been implemented in developed countries (DeCosta et al., 2017). For LMIC, evidence has been limited to pre-post comparisons (Lagerkvist et al., 2018), or randomized control trials with a small sample size (He et al., 2015). While a large body of research studying interventions to reduce undernutrition in developing countries exists, when it comes to promoting healthier food options, such as FAV consumption, existing systematic reviews show a bias for evidence in developed countries (Evans et al., 2012).

School-based interventions can potentially disseminate their messages beyond the school environment; however, the body of literature examining this type of spillover is relatively small.

No conclusive evidence has been found on whether at-school interventions for children lead to dietary changes at home (Taylor et al., 2013). In addition, one question of growing significance in LMIC is whether interventions targeting children can influence other household members. A few studies have shown that providing nutritional knowledge to children can improve the eating behaviors of other household members, such as diet improvements among overweight mothers in Sri Lanka (Gunawardena et al., 2016) and salt intake reduction among households in China (He et al., 2015).

In this study, we carried out a randomized control trial to measure the impacts of a pilot intervention that combines nutrition education and access to healthy foods to increase FAV consumption of children in Viet Nam[19]. Through a cross-randomized design, we aimed to examine the separate and combined impacts of the two components, offering important contributions to the debate on the effectiveness of school-based intervention in LMIC. For this evaluation, we collected extensive at-home and at-school dietary data among almost 2000 children in 12 schools in peri-urban Hanoi. With this rich data set, we can examine the overall effect of the interventions beyond the school environment, for example by accounting for the substitution effect between at-school and at-home consumption.

Our intervention provides nutrition knowledge messages to children and seeks to evaluate whether providing information through children can lead to knowledge, attitude or behavior change among their corresponding parents. We explicitly encouraged children to communicate the nutrition knowledge to their parents and collected outcome data among parents. We can therefore estimate the spillover effects of the intervention onto adult household members.

We developed materials for the interventions in collaboration with the Viet Nam National Institute of Nutrition (NIN) under the umbrella of the National Strategy on Nutrition. Any success in this intervention is therefore poised to go to scale quite easily, particularly as it was designed to minimize any extra burden exerted on teachers. The research findings will be especially helpful for the school nutrition program, which is as a key component of the Viet Nam National Nutrition Strategy until 2030. The strategy stipulates a focus on health and

[19] The study was registered with AEA RCT Registry (RCT ID AEARCTR-0003779). An updated version of the pre-analysis plan was developed in advance of the endline (submitted to Journal of Development Economics).

nutrition education in the school system and the need to develop models to implement school nutrition programs (MoH Vietnam, 2012). Our findings can help draw important policy implications for other LMIC who are implementing nutrition curricula and other school-based interventions. We thereby contribute to evaluating policy-driven interventions on promoting healthy diets through nutrition education and changes in the food environment. Most evidence in this domain has come from research interventions rather than actual programs initiated by government or the private sector (Hawkes, 2013).

The remainder of this paper is organized as follows: In Section 4.2, we describe the school-based interventions , the relevant theories that motivate them as well as our empirical analysis strategy. We then discuss our findings in Section 4.3. Section 4.4 includes the conclusions and a discussion of policy implications.

4.2. Research Design

Sample

The intervention was carried out in Dong Anh district, one of the three focal sites of CGIAR Research Program on Agriculture for Nutrition and Health (A4NH)(de Haan et al., 2017)[20]. Located 15km to the north of central Hanoi, Dong Anh is a suburban district characterized by rapid urbanization, intensive crop-livestock production and important food connections to other provinces. The district holds a typical peri-urban population with a large proportion of migrants from outside Hanoi and a commuting labor force to nearby industrial parks. Although Dong Anh is poorer than the districts in central Hanoi, the district has the lowest poverty rate among peri-urban districts of the city, at 2.9 percent (Dong Anh District Department of Statistics, 2018). As the district makes its way to become classified as urban in 2025, it is increasingly facing issues similar to urban districts of Hanoi. In 2018, up to 42 percent of primary school students in urban areas were overweight or obese, while in rural areas the figure was 18% (Vietnam National Institute of Nutrition, 2019). In the same year, the reported figures for Dong Anh Town primary school was 35 percent and Uy No school was 24 percent

[20] These are the same study sites in the previous chapter (Chapter 3). Due to limited budget, we wanted to set up the study in an existing study site of the program, in order to contribute to a common synthesis. As our study was triggered by the rise of obesity among Vietnamese children, we also wanted to select either a peri-urban or urban area where overnutrition was of greater concern. During our qualitative scoping study, we were convinced that intervening in the peri-urban area would bring more insight, as the urban primary schools already provided better quality meals for the children.

(Dong Anh School health offices, 2018) (Dong Anh School Health Offices, 2018), falling in the middle of the spectrum and causing concerns.

The sample was selected through a multi-stage procedure (Figure 8). Out of 28 primary schools in Dong Anh, 12 schools proposed by the local Department of Education and Training and scattered throughout the district were included in the study. Appendix A shows a map of the district with the schools' locations. In these 12 schools, all 197 classes of grades 3, 4, and 5 were included in the study, and all the children in these classes became our research subjects. The treatments were then administered to all the children in all the classes that belong to the grades to which such treatments were randomly assigned to. We explain how this random assignment was done in 4.2.1 and 4.2.2.

For data collection, we used the student lists provided by the schools to randomly sample 10 children from each class (Figure 8). Although we expected 1970 children in total, the actual sample size at baseline was slightly smaller due to non-response. Some children, including children in the replacement sampling list, were not present on the data collection day, or did not get consent to join by their parents. We had 22 classes from which we had data on fewer than 10 children, so our final baseline sample consisted of 1917 children. The corresponding parents of these children became the subjects of the parent sample.

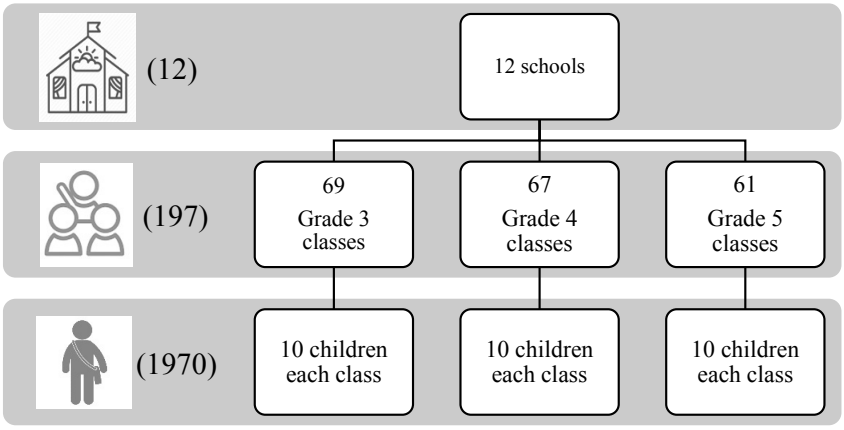


***Figure 8**. Sampling procedure for data collection*

The sampling frame for data collection was obtained directly from the schools, with the support of the district-level Department of Education and Training office. We validated and updated the list of classes and students with the schools before the start of baseline data collection. The sampling frame for children only included those who ate lunch at school; about 80 percent of all students registered to eat lunch daily at school across the 12 schools. By targeting these school lunch eaters, we could more accurately estimate the impact of our interventions by observing their consumption at school.

Experimental Design

The study was designed as a cluster randomized control trial, cross-randomizing the two treatments included. In the first treatment, we provided nutrition lessons for children, focusing on hands-on content and opportunities for children to share their consumption practices. Children were encouraged with rewards to share their knowledge with their parents. In the second treatment, we delivered healthy snacks to classrooms during morning school breaks.

Treatment 1 - Nutrition Information Communication

Rationale for treatment design:

Although nutrition education is currently included in the national curriculum as units in science textbooks, primary-level children do not retain this knowledge well. Our formative qualitative study shows that the heavy cognitive load from other schoolwork prevented children from remembering and understanding nutritional issues, let alone applying them in daily consumption practices. The children found the lessons boring, and they could only recall a generic understanding of a healthy diet. Instead of naming specific health benefits, the children would resort to terms like “containing all the necessary nutrients like fibers, vitamins, minerals” or “balanced in nutrition” to talk about the benefits of eating enough FAV.

In collaboration with the National Institute of Nutrition (NIN), we designed a more integrative approach to nutrition education. In our approach, the lessons can be part of the school meal experience instead of being separate and abstract (Oostindjer et al., 2017). Lunch in Vietnamese schools is typically served in classrooms with all the children eating simultaneously. We timed the nutrition lessons to take place just before lunchtime. This arrangement allowed children to link the knowledge they just acquired with lunch consumption practices. We also kept the nutrition education and communication activities for

children short and relevant, given the limited time and facility available at schools. By not exerting an extra teaching burden on teachers, this proposed approach also has higher replicability, potentially increasing the research's external validity.

Additionally, we included a communication channel for parents to address the lack of communication between parents and schools about children's diets. In general, parents and teachers only communicate about the school meals and children's diets at a parents' meeting occurring once per semester. As it is impossible to involve parents directly in the lessons on a regular basis, we used children to communicate nutrition messages to parents in this study.

Description of treatment:

Messages presented to children focused on balanced diets, recommended daily consumption of FAV, benefits of FAV, and how to incorporate more FAV into their meals. The teachers were trained by NIN specialists to provide these messages to children in five-minute show-and-tell talks right before lunch, for five consecutive weeks. Each week covered a topic, which was presented to children on two different weekdays. Complementing the presentation were leaflets/posters with the same contents. We did not provide extra materials and only remunerated the teachers by lessons, so that no sharing to the control group could take place[21]. The lesson plans, posters and activity guides for each week were developed by NIN in collaboration with the research team. These materials were field tested with teachers and students in two schools in Dong Anh that did not belong to our 12-school sample to optimize their relevance, comprehensibility and applicability.

Children were encouraged to share what they had learned during the nutrition education sessions with their family members. They received small gifts such as storybooks and school utensils for their participation. In the lessons, children were given leaflets bearing the same contents as the lessons for children to share with their parents. Parents were requested to sign a form confirming their receipt of the leaflets, as well as to commit to help children eat more fruits and vegetables. The children brought the forms home with the leaflets and were asked to return the forms to their teachers.

[21] In these Vietnamese primary schools, the teachers are paid based on a fixed number of lessons at each school level in line with the standardized curriculum. Teachers have to be remunerated for any additional lessons on top of this standardized workload. Therefore, they did not have the incentive to teach extra lessons (such as to control classes), on top of the reminder not to do so during the teacher's training.

Treatment assignment:

The 36 grades across 12 schools (three grades per school) served as clusters in our cluster randomization trial, and clusters were assigned to treatments as follows (Figure 9). The schools were first randomly matched into six pairs (A – F). Within each pair: In School 1, one of the three grades, 3rd, 4th, or 5th, was selected as treatment, and the other two grades were placed in the control group; In School 2, the two grades in the control group of School 1 were selected for treatment, and the other grade was placed in the control. In other words, the control-treatment groups mirrored each other in a school pair. As a result, six schools had two grades in the treatment group and one grade in the control group, while the other six schools had one grade in the treatment group and two grades in the control group. Consequently, 18 grades served as treatment clusters, and 18 as the control group.

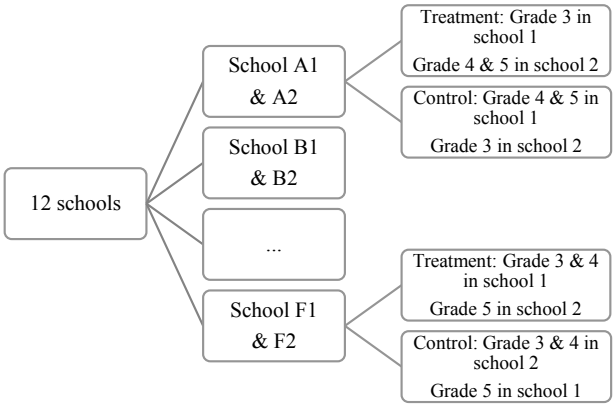


Figure 9. *Assignment of Treatment 1*

Within schools, each grade included between four and eight classes. In the end, out of 197 classes in 12 schools, roughly half were in the treatment group (94) and half in the control group (103) (Table 13).

Table 13. *Results of treatment 1 assignment*

School	Control			Treatment 1		
	Grade 3	Grade 4	Grade 5	Grade 3	Grade 4	Grade 5
A1	4	-	-	-	4	4
A2	-	7	6	7	-	-
B1	4	4	-	-	-	3
B2	-	-	7	7	7	-
C1	6	5	-	-	-	2
C2	-	-	6	7	6	-
D1	4	-	-	-	4	4
D2	-	7	6	7	-	-
E1	-	5	-	5	-	5
E2	6	-	6	-	6	-
F1	4	-	-	-	4	4
F2	-	8	8	8	-	-
Total classes	28	36	39	41	31	22

Although statistical power is sacrificed in this design relative to randomizing classrooms, the design offers several advantages. First, it was easier to convince the schools to participate given that the lessons were to take place in entire grades rather than in selected classrooms across grades. Second, if the treatment is effective, children within grades are more likely to spread messages among their cohort. Under this design, the treatment and control groups are far less likely to interact with one another about the lessons, reducing treatment diffusion at least in the short run.

Treatment 2 - Healthy Food Provision

Rationale for treatment design:

In Viet Nam, fruit and vegetable intake is largely considered insufficient to meet dietary recommendations, with 57 percent of the adult population not consuming five portions a day (T. T. Nguyen & Hoang, 2018). Among children, our formative qualitative work identified FAV as a particularly important class of healthier foods with inadequate consumption among children. Our baseline data within surveyed schools shows that a child typically eats only 87.2 grams of FAV daily, of which 27 grams is fruit. At school, children hardly eat FAV. Although on

average a child is given about 55.7 grams of vegetables to eat during lunch, only a third (18.68 grams) is consumed.

Although vegetables are undoubtedly no less important than fruit, we decided to introduce fruit to the school environment for several reasons. First, fruit is not typically part of the school meal. Children tend to eat a snack in the morning and then lunch in the middle of the day. Whereas schools in urban Hanoi provide snacks, no snack is provided by schools in Dong Anh. Therefore, children either bring their own snacks (e.g. sweetened milk or cakes, seldom fruits or nuts) or buy processed snacks outside schools. The fruit snacks will serve as (i) an outcome measurement to see if the information session motivates children to eat more FAV, and (ii) a default healthier option, which can potentially replace their less healthy snacks. Second, it is much simpler to introduce fresh fruit than vegetables into a specific school's ongoing food preparation scheme. Very few schools in Viet Nam have the facilities to cook vegetables, either by boiling or frying them, on site. Even vegetables that can be eaten raw, which is not popular in Viet Nam, would have to be washed before use. Third, fruit has yet to be recognized as a daily food in Viet Nam, unlike vegetables. In our sample, children only eat fruit five times a week on average, compared with eating vegetables 17 times on average.

Description of treatment:

The snack provision took place over the same five weeks as the education treatment. Budget constraints limited this treatment to two schools. Therefore, in the selected schools, every child in Grades 3 through 5 of these two schools was given a portion (around 80 grams) of fresh seasonal fruits: bananas, grapes or guavas (rotating through the weekdays) during implementation.

We recruited a contractor to supply seasonal fruits as snacks, ensuring the selected company met legal, food safety, and any other school-based requirements to provide food for children at school. For food safety reasons, all the fruits we selected (banana, grapes and guava) had to be peeled or have the skin removed. In early morning, the contractor delivered the fruit directly to teachers, who would then bring the fruit to the classrooms. The children could take the fruit during the morning break so that it did not clash with the on-going school milk program, in which children drink bottled milk during the afternoon break.

Treatment assignment:

To select the two schools for treatment, one out of the six pairs of schools was randomly selected to receive fruit (Figure 10). All the classes of the three grades in these two schools were given fruits as snacks during the morning break. Hence for this treatment, we had 10 schools in the control group and two schools in the treatment group. Accordingly, 30 clusters (165 classes) were in the control group and six (32 classes) in the treatment group.

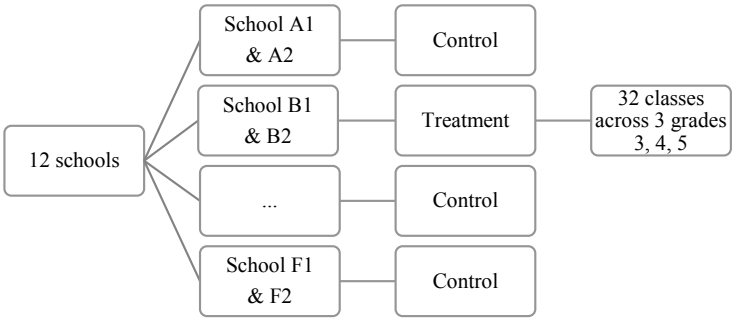


Figure 10. *Assignment of Treatment 2*

In this design, spillover of treatment effect to other schools was impossible. The fruit not consumed by the treated children would simply be transferred to 1st and 2nd graders in the same school, who were not part of the study.

Data Collection

The study involves three data collection rounds: Baseline (four weeks prior to the intervention), Endline 1 (during the last week of the intervention) and Endline 2 (six months after the intervention ended) (Table 2). In each school, the class teachers helped send information sheets and consent forms to participants, and to gather signed consent forms.

Table 14. *Final sample across the three data collection rounds*

	Baseline	Endline 1	Endline 2
Child questionnaire	1,917	1,893	1,240
Food diary collection	1,795	1,887	-
Lunchtime observation	1,879	1,777	-
Parent questionnaire	1,569	1,340	-

Baseline and Endline 1

For the two data collection rounds that took place during the 2018 – 2019 school year, the following data collection tasks were conducted:

- Food diary collection: Enumerators instructed the children to fill in a 3-day food diary with the support of the class teachers. 2 records were for weekday and 1 record for weekend. Every other day (the day following the recorded day), the enumerators checked the diaries to ensure that all the contents in the diary were covered. As the food diary covered a record during the weekend, the enumerators would go back to the same school the following week to collect the diaries. For the treatment group, children recorded for themselves whether they ate the fruit in the food diary. The enumerators who stayed at the school on the day would check the diaries with all the students (both in treatment and control groups) to remind them of any items that they had missed writing down for the day.
- Child questionnaire: The enumerators conducted face-to-face interviews with the sampled children during school breaks.
- Lunchtime observation: An enumerator was assigned a classroom to observe the 10 children and measure their food consumption during lunchtime, for the same day on which the child wrote in their food diary. We only observed children during lunch time where they were seated together and measured what children ate during this time. All children were given the same foods and portions according to the school menu, which facilitated our measurement of leftovers, and recorded the amount of foods (meat, vegetables, rice) the children ate.
- Parent questionnaire: The schools helped the research team obtain contact information (phone numbers) of all parents of the selected students and informed them about the phone interview. The enumerators made phone calls directly to parents to conduct parent interviews.

A detailed description of the data collection tasks and outcome measurements are included in Appendix B. The child questionnaire and 3-day food diary are included in Appendix C.

This study benefited from the use of e-data collection technologies. The interviews were conducted using tablets using the package SurveyCTO. Date entry forms for food diary and

lunch observation data were also developed in SurveyCTO. The forms make use of the 2017 Food composition table (FCT) of Viet Nam (Viet Nam National Institute of Nutrition, 2017). This table consists of 620 foods divided into 15 food groups and 500 dishes in a common Vietnamese recipe book (P. H. Nguyen et al., 2014). The respondents were asked to report cooked food quantity. Where necessary, e.g. the respondents could only report the quantity in raw form, the quantity was converted using a conversion factor taken from the photo book developed by NIN, according to type of processing. A data collection pilot was conducted in two schools in Dong Anh that were not in the primary sample. The objective of the pilot was to check the contents of the questionnaires and the feasibility of the use of food diaries.

Endline 2

The second endline took place in December 2019, during the 2019 – 2020 school year. The children who have graduated from primary school, the 5th graders in the 2018 – 2019 school year, could not be tracked, so only two-thirds of the baseline sample were retained.

In this round, we carried out the same questionnaire-based survey for children, measuring children's knowledge and attitudes, as well as FAV consumption frequency. We did not collect food diaries or conduct lunchtime observations because we did not expect to be able to detect an effect on daily FAV consumption due to the reduction in sample size. Instead, the goal of this survey round was to examine whether any knowledge deterioration had taken place. We are particularly interested in the retention of knowledge taught to the children using the lessons with simple messages. We also did not conduct interviews with parents, due to the lower response rate (82 percent at baseline and 70 percent at Endline 1) and the smaller sample size relative to the previous rounds of data collection, as 5th graders had moved to another school by the 2019-20 school year.

4.3. Results

Balance between treatment arms

We used two approaches to compare treatment and control group characteristics. First, we did a series of linear ordinary least square (OLS) regressions to compare the nutrition education lessons treatment group ("Lessons" treatment) with the Control group, and the fruit provision treatment group ("Free fruit" treatment) with the Control group, using treatment variables

and explanatory variables obtained from our baseline questionnaires (Table 15). Second, we conducted a joint test of orthogonality using a χ^2 test. We ran a binary logit with the treatment variable on the left-hand side, and explanatory variables on the right-hand size. The null hypothesis is that all the regression coefficients across two models (for three treatment values) are simultaneously equal to zero. In both approaches, we used clustered standard errors to account for the randomization process.

***Table 15**. Baseline variables*

Variables	Type	Description	Mean	SD
Child				
Knowledge index	Continuous	The scores from the knowledge questions were aggregated into a mean effects index (Kling et al., 2007). The control group takes the mean 0 and standard deviation 1.	-0.02	1.00
Attitude index	Continuous	The scores from the attitude questions were aggregated into a mean effects index (Kling et al., 2007). The control group takes the mean 0 and standard deviation 1.	0.05	0.98
Consumption frequency (fruit)	Continuous	The number of times the respondent ate fruit in the past 7 days	7.08	5.24
Consumption frequency (vegetable)	Continuous	The number of times the respondent ate vegetable in the past 7 days	16.56	8.24
Male child	Dummy	0 = No; 1 = Yes	0.56	0.50
Age of the child	Continuous	8 – 14 years	9.96	0.82
Parent				
Knowledge index	Continuous	The scores from the knowledge questions were aggregated into a mean effects index (Kling et al., 2007). The control group takes the mean 0 and standard deviation 1.	-0.01	1.02
Attitude index	Continuous	The scores from the attitude questions were aggregated into a mean effects index (Kling et al., 2007). The control group takes the mean 0 and standard deviation 1.	-0.05	1.01
Consumption frequency (fruit)	Continuous	The number of times the respondent eats fruits in the past 7 days	11.09	6.70
Consumption frequency (vegetable)	Continuous	The number of times the respondent eats vegetables in the past 7 days	18.48	8.11
Male parent	Dummy	0 = No; 1 = Yes	0.16	0.37
Household size	Continuous	1 – 10	4.51	1.21
Household income quartile	Categorical	1. 1st income quartile (least well-off) 2. 2nd income quartile 3. 3rd income quartile 4. 4th income quartile (most well-off)	2.37	1.18

For the child sample, using the first approach, we found no statistically significant difference between the Lessons and Control groups, and between Free fruit and Control groups (Table 16). The second approach came to a similar conclusion (Table 17). With p-value > 0.05 (Prob > χ^2 = 0.50), we could not reject the null hypothesis, which implies that Lessons and Control were similar on the explanatory variables. Between Free fruit and Control, we rejected the null hypothesis (p-value < 0.05), as there was an imbalance in the knowledge index score. This slight imbalance could have been expected given the sample size imbalance and the small number of clusters for the second treatment (Table 17). We had only six (32 classes) in the treatment group compared to 30 clusters (165 classes) in the control group.

For the parent sample, using both approaches, we found virtually no difference between Lessons and Control. Nevertheless, we detected some differences in baseline variables between Free fruit and Control, which also could have been expected due to the imbalance and small number of clusters in the sample of children. Besides, the parent sample had a higher non-response rate than the child sample. Via phone calls, we could only reach 1570 parents, compared to 1917 children. Checking for missing data reveals that non-response rate was higher among some schools, including the two schools in the Free fruit treatment group, than the others. The difference between Free fruit and Control on the consumption frequency of vegetable was small (1.5) and only significant at 10 percent level. The differences on the knowledge and attitude variables are more of a concern, which require caution in analyzing the data to calculate treatment effects on the parent sample (Table 17).

***Table 16**. Regressions of Outcome Variables Measured at Baseline on Treatment Indicators*

Child	Knowledge index	Attitude index	Consumption frequency (fruit)	Consumption frequency (vegetable)	Age	Male
Treatment 1: Lessons	-0.04	0.10	0.45	1.11	-0.32	0.03
	(0.08)	(0.07)	(0.31)	(0.81)	(0.27)	(0.03)
Treatment 2: Free fruit	-0.12	0.07	0.51	-0.47	0.01	0.06
	(0.08)	(0.12)	(0.50)	(1.33)	(0.38)	(0.04)
Observations	1,917	1,917	1,917	1,917	1,917	1,917

Parent	Knowledge index	Attitude index	Consumption frequency (fruit)	Consumption frequency (vegetable)	Male	Household size	Household income quartile
Treatment 1: Lessons	-0.03	-0.10	0.13	1.64	-0.00	-0.18*	-0.00
	(0.08)	(0.08)	(0.56)	(1.08)	(0.03)	(0.09)	(0.08)
Treatment 2: Free fruit	0.16**	-0.16**	0.25	-1.57*	0.03	-0.08	-0.07
	(0.06)	(0.06)	(0.41)	(0.81)	(0.04)	(0.06)	(0.08)
Observations	1,570	1,570	1,570	1,570	1,570	1,569	1,570

Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

***Table 17**. Test of joint orthogonality using logistic regression*

Child	Treatment 1: Lessons	Treatment 2: Free fruit
Knowledge index	-0.0102	-0.12*
	(0.0699)	(0.06)
Attitude index	0.0725	0.09
	(0.0640)	(0.13)
Consumption frequency (fruit)	0.00972	0.02
	(0.0136)	(0.02)
Consumption frequency (vegetable)	0.00535	-0.01
	(0.0102)	(0.01)
Age	-0.465	0.02
	(0.413)	(0.07)
Male	0.125	0.24
	(0.118)	(0.16)
Constant	4.296	-1.93
	(4.151)	(1.17)
Observations	1,917	1,917
chi-square test	5.375	76.25
p-value, Chi-square test	0.497	0.000

Parent	Treatment 1: Lessons	Treatment 2: Free fruit
Knowledge index	-0.03	0.18***
	(0.07)	(0.06)
Attitude index	-0.09	-0.15***
	(0.08)	(0.05)
Consumption frequency (fruit)	-0.00	0.02
	(0.01)	(0.01)
Consumption frequency (vegetable)	0.03**	-0.03***
	(0.01)	(0.01)
Male	-0.07	0.22
	(0.20)	(0.34)
Household size	-0.14**	-0.03
	(0.06)	(0.05)
Household income quartile = 2	-0.01	0.15
	(0.17)	(0.20)
Household income quartile = 3	0.12	-0.16
	(0.19)	(0.29)
Household income quartile = 4	0.03	-0.12
	(0.18)	(0.20)
Constant	-0.02	-1.21
	(0.55)	(0.88)
Observations	1,569	1,569
chi-square test	16.15	112.8
p-value, Chi-square test	0.0638	0.000

Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Treatment effects

Short term treatment effects on children

We estimated the intention to treat (ITT) effects of the treatments using the following specification:

$$y_{ij} = \alpha_0 + \alpha_1 L_j + \alpha_2 F_j + \alpha_3 L_j F_j + X'_i\beta + \epsilon_{ij} \quad (1)$$

The effect of the nutrition lesson (L), free food provision (F) and the interaction between the two treatments (LF) is given by α_1, α_2 and α_3, respectively. y_{ij} includes the outcome measure at endline for individual i in cluster j. Although fruit provision was randomized at the school level, we used 36 clusters for both treatments. For baseline outcomes, the intra-cluster correlation (ICC) at both the school and grade levels were both small (ranging from 0.01 – 0.07) and not meaningfully different from one another, suggesting that clustering at the grade level should sufficiently account for intra-cluster correlation. X'_i is a vector of baseline covariates (controls).

Knowledge and Attitudes:

In the short term, the nutrition lessons had a moderate positive effect on the children's nutritional knowledge (Table 18). Using an OLS regression under specification (1), we found that on average the children who were offered the lunchtime nutrition lessons gained 0.33 standard deviations in the knowledge index score. We obtained similar results when we added socio-economic control variables or the baseline value covariates (Columns 2 and 3). Although we expected combining both interventions to have an additional influence on the knowledge score due to the knowledge-practice connection, we did not find an additive effect.

Contrary to expectations, neither the nutrition lessons nor fruit provision led to a significant change in children's attitudes about FAV consumption. This result is consistent across the three specifications in Table 19. The combined intervention appears in some specifications to raise attitudes of children towards eating FAV by around 0.3 standard deviations, but it is only statistically significant at the 10 percent level in two of the three specifications. The relatively small sample of 146 children who got the combined intervention may help explain the lack of significance.

***Table 18**. Short term treatment effect on children's nutritional knowledge*

	(1)	(2)	(3)
Knowledge index	No controls	With socio-economic controls	With baseline value of outcomes
Education lessons	0.33**	0.44***	0.41***
	(0.13)	(0.10)	(0.08)
Fruit provision	-0.00	0.07	0.03
	(0.11)	(0.11)	(0.09)
Interaction	-0.03	-0.18	-0.06
	(0.15)	(0.17)	(0.15)
Male child	-	-0.07	-0.09*
		(0.06)	(0.04)
Age of child	-	0.27***	0.24***
		(0.03)	(0.03)
4^{th} income quartile	-	0.23***	-
		(0.08)	
Household size	-	-0.05**	-
		(0.02)	
Male parent	-	0.02	-
		(0.0675)	
Knowledge index (baseline)	-	-	0.23***
			(0.02)
Constant	0.00	-2.52***	-2.34***
	(0.09)	(0.36)	(0.32)
Observations	1,893	1,501	1,891
R-squared	0.02	0.09	0.12

Cluster robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 19. Short term treatment effect on children's attitude index on FAV consumption

	(1)	(2)	(3)
Attitude index	No controls	With socio-economic controls	With baseline value covariate
Education lessons	0.03	0.02	-0.01
	(0.04)	(0.04)	(0.05)
Fruit provision	-0.16	-0.02	-0.14
	(0.19)	(0.17)	(0.12)
Interaction	0.35*	0.29	0.26*
	(0.20)	(0.18)	(0.13)
Male child	-	-0.10*	-0.08
		(0.06)	(0.05)
Age of child	-	-0.09***	-0.05*
		(0.02)	(0.03)
4th income quartile	-	-0.03	-
		(0.08)	
Household size	-	0.02	-
		(0.02)	
Male parent	-	-0.04	-
		(0.06)	
Baseline attitude index	-	-	0.39***
			(0.02)
Constant	0.03	0.91***	0.60**
	(0.03)	(0.27)	(0.28)
Observations	1,893	1,501	1,891
R-squared	0.01	0.02	0.17

Cluster robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Additional explanatory data from the questionnaire reveals some clues why children are not willing to eat more FAV, despite the increased awareness of the importance of eating FAV. Eighty-five percent of the children cited the reason for their difficulty in increasing their FAV is that FAV do not taste good. This identified constraint is in line with our qualitative findings, which found that the lack of tastiness in FAV, especially those prepared at school, led to low FAV consumption. In the qualitative scoping study, the children complained that vegetable dishes served at school were too cold and/or too oily. Not surprisingly, at school, a child consumed only about 25 grams of FAV on average, while at home this figure is about 95 grams.

Consumption

From the food diaries and lunchtime observation data, we calculated two outcome measures for children's consumption: the amount of fruit and vegetable consumed in a weekday and the amount of fruit consumed per weekday (in grams)[22]. Table 20 displays the results of the OLS regressions to estimate the ITT of the interventions on these two consumption outcomes. Columns (2), (4) and (5) include control variables[23].

[22] Although we also collected food diaries of one weekend day, many children failed to fill them in by themselves (without the enumerators by side to assist them and control that the diaries were filled in). During weekends, for example, we only got 77 percent as large a diary sample compared as on weekdays, and many fields were left blank on returned diaries in general. We therefore decided to exclude them from the analysis.

[23] The number of observations under columns (1) – (5) is much lower than that of the baseline (1917) and the previous endline knowledge and attitude estimations (1893) for several reasons. First, the knowledge and attitude measures were obtained from the face-to-face questionnaire with the children, while the consumption outcome measure had to be calculated from both the food diary and food observations. We had a large proportion of children (12%) who did not return their diaries, while we had only 4% of the children who could not be observed during lunchtime. The number of missing observations for food observation is small and does not qualitatively affect the results of the following analyses.

Table 20. *Short term treatment effect on children's FAV consumption and fruit consumption*

VARIABLES	(1) Daily FAV consumption No controls	(2) Daily FAV consumption With controls	(3) Daily fruit consumption No controls	(4) Daily fruit consumption Child level controls	(5) Daily fruit consumption Parent level controls	(6) Weekly fruit consumption No controls
Education lessons	-10.89	-8.616	-0.491	1.165	-1.108	0.54
	(7.074)	(7.500)	(3.986)	(3.563)	(3.365)	(0.34)
Fruit provision	30.75	41.79	34.84**	35.73*	33.03	2.25*
	(27.38)	(38.68)	(16.41)	(17.81)	(25.58)	(1.25)
Interaction	28.69	21.03	-7.821	-8.027	-1.530	0.00
	(34.40)	(42.28)	(22.27)	(21.71)	(27.70)	(0.00)
Male child	-	-13.97**	-	-9.673**	-11.13**	-
		(5.779)		(3.627)	(4.095)	
Age of child	-	5.575	-	3.994	2.323	-
		(5.493)		(3.186)	(3.260)	
2nd Income quartile	-	14.10*	-	-	12.90*	-
		(8.255)			(7.035)	
3rd Income quartile	-	18.24***	-	-	12.49*	-
		(6.597)			(6.954)	
4th Income quartile	-	3.330	-	-	4.277	-
		(7.039)			(4.729)	
Household size	-	-1.445	-	-	-1.918	-
		(2.767)			(2.012)	
Male parent	-	-1.815	-	-	8.175	-
		(6.618)			(5.536)	
Control group Mean	123.97	123.97	27.41	27.41	27.41	7.08
Control group SD	104.34	104.34	71.05	71.05	71.05	5.42
Observations	1,557	1,242	1,557	1,556	1,242	1,893
R-squared	0.030	0.043	0.026	0.033	0.036	0.03

Cluster robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Education lessons did not influence the fruit and vegetable consumption, which was not surprising given their lack of influence on the attitude towards fruit and vegetable consumption and the short intervention time span. Access to free fruit, nevertheless, increased children's consumption. Although we provided every treated child a full portion of fruit (80 gram), less than half of this (34.84 grams) was consumed by the children on average. This amount still doubled the daily fruit consumption of children compared with the control group, who ate less than 30 grams of fruit on a weekday (equivalent to a small mandarin or a piece of mango). The effect remained significant (albeit at a p-value = 0.053) when we included the child-level control variables but lost its statistical significance when we included the parent's control covariates. As discussed above, attrition in the parent sample was higher among some schools, including the two schools that got the Free fruit treatment. This may have weakened the detected effect of this treatment when including the parent-level controls. When we used the weekly fruit frequency consumption as the outcome measure, fruit provision increased the times the child consumed fruit by two (Column 6 of Table 20), which was less than half the times they got access to free fruit (five times a week). This measure is arguably not as reliable as the daily consumption measure, as the child had to recall over a longer period (a week) instead of make food records every day.

We also separately looked at the amount of fruit consumed at school and at home to explore potential substitution effects. By "home", we meant the children's own home, excluding in-school and out-of-home consumption.[24] Table 21 displays the results of the OLS regressions. It was clear that the increase in fruit consumption was exclusively driven by the free access at school. The increase in fruit consumption at school was not offset by a decrease in fruit consumption at home.

[24] The other places encompassed a very small proportion of the responses. For example, on the first day of the food diary, only 2.21% and 1.34% of the children ate at other places than home and school at breakfast and dinner, respectively.

Table 21. *Daily fruit consumption at school and at home*

VARIABLES	(1) Fruit consumption At school, weekday	(2) Fruit consumption At home, weekday
Education lessons	-1.256	1.225
	(1.174)	(2.847)
Fruit provision	34.88***	1.066
	(12.01)	(5.500)
Interaction	-12.38	1.437
	(16.84)	(6.180)
Constant	3.719***	20.44***
	(1.015)	(2.197)
Observations	1,557	1,557
R-squared	0.190	0.000

Cluster robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Short term treatment effects on parents

For the parents, we only estimated the intention to treat (ITT) effects of nutrition lessons using the following specification:

$$y_{ij} = \beta_0 + \beta_1 L_j + X_i'\gamma + \epsilon_{ij} \quad (2)$$

The average effect of the nutrition lessons (L) is given by α_1, y_{ij} includes the outcome measure at endline for individual i in cluster j, and X_i' represents covariates.

Although we incentivized all treated children to share the materials that they had obtained at school with their parents, many parents did not receive the materials. Out of 644 parents whose children were given the nutrition lessons in our endline sample, only 41.8 percent of them confirmed receiving the materials. And only 44.6 percent of the parents who received the materials from their children could recall at least one topic covered in the materials.

Consequently, it came as no surprise that the education lessons taught to the children created no significant changes in knowledge and attitudes among parents (Table 22). The results did not change qualitatively when we included control variables or when we used the local average treatment effect (LATE) estimator with the treatment status instrumenting for actual receiving the leaflets (Appendix D). Although the education lessons raised the reported FAV consumption frequency by 1.64 times per week25 (ITT estimate) and 3.94 per week (LATE estimate), this result is likely to be at least partly driven by social desirability bias. This effect on consumption also lost its significance when we included baseline value of the FAV consumption frequency in the regression (Appendix D).

***Table 22**. Treatment effects on parents*

	(1)	(2)	(3)
VARIABLES	Knowledge index	Attitude index	FAV consumption frequency
Nutrition lessons	-0.0558	-0.0996	1.642*
	(0.0687)	(0.102)	(0.894)
Observations	1,340	1,340	1,340
R-squared	0.001	0.002	0.011

Cluster standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Longer term treatment effects on children

We applied the same specification (1) to the second endline data, which was collected six months after the treatment ended. We were mainly interested in how the knowledge taught to the children retained after the long summer holidays and wanted to assess the longer-term effect of the interventions on the knowledge and attitude towards FAV consumption of the

[25] Although we also collected diaries from parents, the quality of these diaries was generally poor. A large number of parents did not return the diary (we only received 1174 diary books out of 1340 interviewed parents). For those that did, the information provided was not detailed enough to calculate the amount of consumed FAV correctly. This would lead to underestimation of the FAV consumption. If we used this FAV amount as outcome measure instead of the consumption frequency, the qualitative result did not change.

children. We did not collect consumption outcome data, so our result does not include analysis on consumption.

The main effect of the education lessons that we observed in the short term became negative in the long term (Column 1 Table 23). After the summer holidays, the children who were given the lessons had a lower knowledge index score relative to the control group. This seemingly surprising result was driven by one question, out of a dozen questions that made up the index, on the variety of fruits and vegetables that one should eat. For this question, the child was given a description of an eating habit and was asked to judge if it was a healthy one. This habit involves eating only fruits instead of vegetables. In Viet Nam, fruit is generally not consumed as much as vegetables, and the nutrition lessons may unintentionally have played up the role of fruit. Eating more fruit may have been stickier to the treated children's memory, and they may have misjudged that eating only fruit can be as beneficial as eating both. Control children were not exposed to the lessons, and therefore held on to their usual notion that they should eat both fruit and vegetables.

Table 23. *Longer term treatment effects*

VARIABLES	(1) Knowledge index	(2) Knowledge index (with controls)	(3) Attitude index
Education lessons	-0.17*	-0.14*	-0.02
	(0.10)	(0.08)	(0.07)
Fruit provision	-0.08	-0.05	0.07
	(0.11)	(0.06)	(0.14)
Interaction	0.29**	0.24**	0.02
	(0.13)	(0.09)	(0.17)
Male	-	0.02	-
		(0.05)	
Age	-	0.17***	-
		(0.06)	
Baseline knowledge index	-	0.18***	-
		(0.03)	
Constant	0.01	-1.61***	-0.01
	(0.07)	(0.57)	(0.04)
Observations	1,240	1,240	1,240
R-squared	0.01	0.05	0.00

Cluster standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Similar to the case in the short-term endline, we did not detect a change in the attitude of the children toward fruits and vegetables when exposed to either of the interventions.

4.4. Discussion and Conclusions

Our study designed and tested a pilot intervention to improve children's consumption of fruits and vegetables through schools in Viet Nam. We estimated the effects of two interventions through a randomized control trial on over 1900 children in 12 schools in peri-urban Hanoi. Evaluation data was collected immediately after the intervention and six months after the interventions had ended.

We found that the nutrition lessons had a significant effect on improving children's knowledge of FAV. The five-week-long short and relevant nutrition lessons increased the knowledge score by 0.3 standard deviation compared to the control group. The interventions were implemented inexpensively and conveniently for the schools without extra burden for teachers. Besides a one-off cost for developing the materials based on existing nutrition materials available at NIN, we only had to pay for the printing of posters and leaflets delivered to children and remuneration for teachers. This amounted to approximately US$40 per class for the whole intervention package. Therefore, if the purpose of a school nutrition program is to raise knowledge, our one-shot intervention can be a cost-effective way to raise the children's nutritional knowledge. Where resources are tight, this can be a desirable alternative to a full-scale nutrition curriculum, which is being piloted in a limited number of schools in Vietnam.[26]

Regarding child motivation to eat, our pilot intervention failed to change the attitude and motivation to eat healthier foods. In our education intervention, we talked about the benefits of FAV, including direct benefits to their own health. This approach was motivated by the application of self-determination theory in health behavior change, in which identified regulation (e.g., acting to obtain personally valued outcomes) can autonomously motivate individuals (Gillison et al., 2019). To illustrate, to explain the benefits of FAV, we used verses explaining how eating healthy can help children reach certain goal (e.g. to do well in sports, to have good grades in school). The best way to increase children's motivation to eat healthy food

[26] The program "School nutrition education – Nestle for healthier kids" implemented by Primary Education Department (Ministry of Education and Training), National Institute of Nutrition and General Department of Preventive Medicine (Ministry of Health) have been implemented since 2012 in 60 primary schools in 9 provinces (not including Hanoi) in Vietnam. The curriculum for the program includes 16 topics (complemented with interactive slides to be used on computers) and is complemented with other activities like school competitions and school gardening (http://dinhduonghocduong.net/ (only in Vietnamese)

would have been to make them act for the inherent enjoyment of the activity involved. This was a big challenge, given the perceived poor quality of the food, which we discuss shortly.

We were not disappointed to find a lack of impact of the lessons on the FAV consumption of the children. From scoping qualitative interviews, we understood the poor quality of the meals provided to children during lunch. This supply-side constraint must have prevented the children from eating more fruit and vegetables, even though they were better aware of the issues of not eating enough FAV. Our follow-up qualitative interviews with the children confirmed this speculation: the children could not raise their FAV consumption although they wanted to because the vegetables prepared at school tasted bad. Unless the schools are willing to work with the food providers to improve the meals' quality, nutrition education about increasing FAV consumption might lose its effectiveness. During qualitative interviews, school officials also expressed their wish to improve lunch time meals, but barriers to improving lunches are budget constraints (parents are not willing to pay more for lunch at school), facility constraints (only one school out of 12 schools had a separate lunchroom, no school had a separate kitchen, let alone meeting food safety standards) and human resources (caretakers for the lunchroom, kitchen staff).

Access to healthy and safe food at school can be an effective measure to raise children's healthy food consumption. A common excuse by parents regarding children's low consumption of healthy foods is that the children do not like to eat such foods and making the fruit available will not help. We proved that it is not the case here. We did not observe a substitution effect between fruit provision at school and home fruit consumption, suggesting that, given the access to healthy and safe food at school, children will gladly consume more of it without offsetting the amount of fruit they eat at home. Providing children with free and accessible FAV has been shown to have an impact on long-term eating behavior (DeCosta et al., 2017). Although we did not have the resources to implement this in the long run – it is worth considering including fruit in the school food environment. The short duration of our pilot fruit provision intervention did not allow us to measure its effectiveness on habit formation, which can be achieved with a larger-scale program. For example, a one-year implementation of the European School Fruit scheme led to a significant increase in children's FAV consumption (Methner et al., 2017). School food programs are not foreign to Viet Nam. A school milk program has been implemented in several provinces in Viet Nam, including Hanoi.

Nevertheless, the healthiness of this initiative is questionable because the majority of milk provided is sweetened and a proper evaluation has not been conducted. Our study suggests that inclusion of fruit during school time worked effectively to increase healthy consumption, and natural fruit is superior to sweetened milk as snacks. The habit of adding sugars to foods that are commonly perceived as healthy such as milk may impact the adherence to healthy dietary guidelines and increase in adiposity risk (Russo et al., 2018). The amount of fruit eaten by an average child per day is as low as one portion, which has to be raised without a doubt. One important concern is food safety, which we could ensure in our pilot, but might be difficult to acquire in other settings. As our qualitative scoping study revealed, most schools in the area have focused on measures to ensure the lunch has a low risk of food contamination (e.g. never offer salads and less leafy greens as these are believed to have higher residuals of pesticides), trading off food diversity for food safety. Serving fruit at school could be challenging for the same concern.

Child-parent message delivery is seemingly not an effective channel for nutrition knowledge dissemination in our setting. Although the children were encouraged to deliver the nutrition messaging to their parents, the majority of the parents did not receive/recall receiving this information, thus displaying no changes in their knowledge, attitude or practices of FAV consumption. In our follow-up qualitative interviews with the children, they talked about the following reasons for this result: the parent had no time to read the information; the child did not attempt to share the information knowing that his or her parent would not read it; the child did not remember to relay the information to their parents. Admittedly, during the short lessons in school, the child might have not been given enough communication and persuasion skills to follow up with their parents.

The children who successfully delivered the salt-reducing message to their family members in an earlier study received training in 3.5 months, with several homework tasks to do as messengers (He et al., 2015). As our intervention was designed to introduce minimal disruptions to a school day, we did not have dedicated time to train the children. Counting on the children to deliver the information was only part of the problem. Parents' willingness to receive the information from school through their children is low in Viet Nam. Our follow-up qualitative questions with the students revealed that some children did not even attempt to relay the health messages to their parents, believing that the parents would not consider such

information. In peri-urban schools in Viet Nam, although information from school frequently reaches parents through letters delivered by the children, the parents usually took notice of only important events such as final term parents' meetings. Apparently, the information relayed by the students from school education was not given such importance. Although we set up a hotline for the parents in our study to share their concerns and wishes about the children's diets, we received virtually no reactions. Rallying the participation of parents given the resource constraints is a challenge that future actions will have to overcome.

As a field experiment, our study faced particular risks to both internal and external validity. Although the teachers had no incentive during the duration of the treatment and first endline data collection to provide formal lessons and share the educational materials with students in other grades, we could not ensure they would not include the knowledge they gained from the intervention into their own teaching practices, for example in science lessons. If such channels did occur, we may have underestimated treatment effects. Another concern that affects the study's internal validity is that the treated children's siblings and friends that belonged to control group may have picked up some knowledge from the treated children. Again, such transmission would have led to underestimated treatment effects. To assess the extent of this problem, we identified these spillover children in the baseline and interviewed them in the first endline. The spillover children did not have a higher knowledge score than our pure control children, which suggests that the results remain internally valid. However, this finding also suggests the knowledge did not circulate within the children's extended network (beyond their specific grade). Our measurements may also suffer from underreporting, as it was mostly the children's responsibility to fill in the food diaries themselves. The use of the food diaries by parents was also very limited. Future studies may consider the use of a more interactive tool, for example a child-friendly mobile app that the child can fill in together with their parents, to increase response rate and completeness of dietary data collected from both children and their parents.

Regarding external validity, our results are specific to our sample. Our sampling frame only included children who have lunch at school, which enabled us to observe their consumption at school and provide better estimate of total consumption. Nevertheless, those who do not have lunch at school may have certain characteristics that must be taken into account: for example, they may have better food at home, but eat less at home due to the lack of peer pressure and

social eating environment. Recruitment of the schools was not randomized, as the Department of Education and Training wanted to give preference for the schools with the least exposure to external interventions. Although this procedure does not ensure the representativeness of the study, it has the advantage of giving the less exposed schools access to pilot interventions. If the pilot works in these schools, it should also have potential to be effective in more exposed schools. Besides, the intervention materials must be adapted to fit other contexts. The teachers' skill and the school's facilities would also determine the outcomes of the nutrition lessons. We also provided teachers with a small incentive to ensure they taught the lessons, which might be difficult to scale. The availability and accessibility of fruit and vegetables in the school environment would also influence the effectiveness of treatments similar to the ones in this experiment.

Our focus on FAV, while attempting to address a specific dietary recommendation for Vietnamese children, posed another limitation. As FAV is part of a multi-food-group diet, an intervention that affects FAV consumption can as well affect consumption of other foods. Unlike FAV, there is not yet a consumer-friendly guideline (e.g. 5 portions a day) for consumption of other foods such as meat or fish. Taking account of and calculating the consumption value of other groups would require a much greater data collection and analysis effort, as well as a database of national dishes, including processed foods, which is not yet available for Viet Nam. Only when this knowledge base is available will we be able to look at the relationship between FAV and other food groups. Additionally, consumption of FAV, like other food groups, is shaped by cultural and socio-economic contexts. FAV are therefore part of context-specific system of eating occasions, dishes, ingredient pairings etc. (Cuevas et al., 2017; Samaddar et al., 2020). Nutrition interventions such as this one can be improved by recognizing these cultural and systemic drivers and identifying entry points in this system. For example, traditional Vietnamese dishes tend to be rich in vegetables which are combined with other ingredients like meat and fish. The messages on promoting FAV could be more nuanced, e.g. promoting healthy dishes that are high in vegetables. Similarly, as Vietnamese prefer a hearty full meal-like breakfast, e.g. a full bowl of pho noodles, promoting a new eating occasion for fruit consumption (e.g., eat an apple as dessert for breakfast) could be a viable option. Future studies could benefit from this recognition of context-specific culinary systems to enrich their intervention approaches.

Policy implications

As discussed in the introduction, our study results provide useful considerations for the implementation of Viet Nam's national nutrition strategy where school-based nutrition is a vital component. We identified the short nutrition lessons as a viable, inexpensive option to raise the knowledge of young children. Developed by government nutritionist partners, the lessons have been standardized to meet the national health recommendations, and they can also be adapted to fit different contexts. Nevertheless, we recommend additional considerations. First, the design of education lessons should prevent beneficiaries from overly focusing on specific recommendations and forgetting to diversify their diets. We found that the effect of nutrition lessons on knowledge can become negative in the longer term, possibly driven by children's overemphasis on fruit consumption rather than on both fruits and vegetables. Second, we recommend inclusion of fruit and improvement of lunch meal quality to bridge the knowledge and practice gap. As long as the food providers do not make substantial changes to how vegetables are served at school, the children will not change their attitudes toward the consumption of such dishes. These supply-side measures would require commitment of resources from both schools and families, and more support from the government. Initiatives exist to improve the school meal quality, such as the School Meal Project27, implemented by Ajinomoto, the Ministry of Education and Training and National Institute of Nutrition. Nevertheless, the school food suppliers in Dong Anh assessed the current menu planning tool to be infeasible given the local contexts. For example, the menu includes salads, which are difficult for the providers given the higher level of hygiene required to serve fresh uncooked vegetables. It remains a challenge to help schools develop school meals that are nutritious, tasty and locally adaptable.

Our study also advocates for the introduction of fruit into the school environment. Currently, in Viet Nam, only some better-off schools in urban areas provide fruit as snacks for primary school children, mostly because they have better access to safe fruit providers and the parents have higher income to pay for the fruit. To realize our recommendations and bring fruit to more schools, both constraints would have to be relaxed, particularly with support from the government and the private sector. Policy makers can ideally build upon lessons they have

[27] http://buaanhocduong.com.vn/ (in Vietnamese only)

learned with their current experience with the school milk program, to extend that program to include fruit and vegetables. The progress and lessons from developed countries, such as the EU school fruit, vegetables and milk scheme, will also be helpful for considerations. Suggestions for policy makers include campaigns on parents to invest more in children's lunches, partly supported by the government. Nevertheless, the weak link between parents and school has to be addressed before implementing such recommendations.

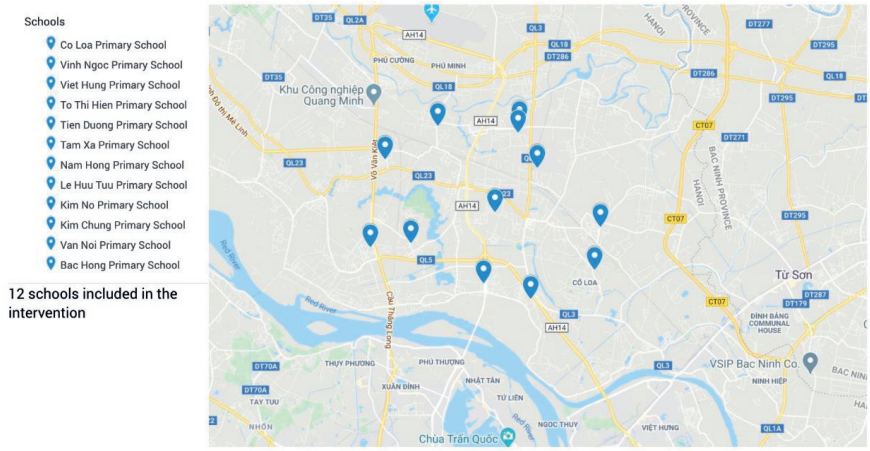
We also raised concerns about family participation in improving children's diets. The National Nutrition Strategy states that improper nutrition knowledge and practices are still common among mothers and other family members, including those living in less developed areas, and that participation of communities and family members should be encouraged. The strategy, however, does not specify how to achieve the participation of family members. Parental involvement has been identified as a success criteria for school-based interventions in preventing childhood obesity in middle income countries (Singhal et al., 2020). Our intervention did not successfully reach the parents, as there were no effective communication channels between parents and schools. Meanwhile, the children were not equipped with skills to act as the bridge. This limitation does not concern only our research, but also fits into the broader pitfall of school—home communications. Therefore, educators and policy makers will have to come up with innovative tools to remove barriers to improved school—home communications. For example, online platforms such as Facebook have been assessed to help overcome the time constraints parents face in accessing nutrition education (Swindle et al., 2018). Future research can search for school-based nutrition tools to which parents will positively respond.

Our findings reflect those by recent systematic reviews on effectiveness of school-based nutrition interventions and food environment interventions on anthropometric outcomes in school-aged children and adolescents in LMICs (Kyere et al., 2020; Singhal et al., 2020). For example, in sub-Saharan Africa, after reviewing a number of RCTs that sought to improve nutritional knowledge and outcomes, the authors concluded that although interventions are effective in improving nutrition knowledge, they may have little impact on nutritional outcomes without a facilitating environment (Kyere et al., 2020). Policymakers in the education sector planning were therefore suggested to consider including nutrition education in formal school curricula. Our short and cost-saving model of nutrition knowledge building could be a

relevant option. Nevertheless, besides the education barrier, lack of influence that children have on their food choices, food poverty and accessibility were also considered challenges to a change to healthier diets. As identified in our research, supply-side constraints and household-level affordability are important barriers to children's increased intake of FAV. It has been suggested that policies to increase intake of FAV should enhance availability as well as affordability (Miller et al., 2016). School-based policies to increase consumption of fruit and vegetable are one of the main themes of policies/action plans/guidelines in LMIC, but only a few countries have strategies to meet the WHO recommendations, missing comprehensive and adjuvant policies addressing agricultural and poverty issues (Darfour-Oduro et al., 2019). To improve the facilitating environment for consumption of healthier food, including FAV and contribute to a holistic strategy, school nutrition programs should be part of a broader framework of food system interventions. Opportunities to intervene in food systems and environments include increasing (safe) production of fruits and vegetables and linking school-based programs to community and household-level approaches (Canavan & Fawzi, 2019).

Appendices

Appendix A: Map of schools in Dong Anh



The map is available at the following address:

https://drive.google.com/open?id=1SnFXKA1v_qVb3W38sJqImJ2hWTL102bk&usp=sharing

Appendix B: Outcome measure and Collection method

Subject	Outcome Measure	Data collection Method
Child	Knowledge and attitude about fruits and vegetables	A questionnaire was administered to the sampled child through Survey CTO by trained enumerators. The questionnaire was developed based on FAO Guidelines for assessing nutrition-related Knowledge, Attitudes and Practices (2014). The knowledge questions were adapted based on the topics covered by the intervention's material kits.
	School consumption	In Dong Anh, all school lunches are provided in food trays with standardized foods (portioned by the school food provider staff). The enumerators measured 3 standardized food trays for each grade. At the start of lunch time, enumerator handed out the food trays (with stickers to identify the sampled children). After children finished eating, they collected the identified trays, measured the leftover (or extra food – the enumerator could see if he/she asked for extra food from the teacher/enumerator; and/or estimated the amount of food she/he was given by another student) using a standardized food scale and filled in the school food diaries for each child.
	Home consumption	Children's home food consumption is recorded using a 3-day food diary (Prentice et al., 2011). The diary covers 2 days of the school week and 1 weekend day. A class was randomly assigned to one of the 2 schemes: (1) Tuesday, Thursday and Saturday or (2) Wednesday, Friday and Sunday. We had no records for Mondays for two reasons: - The enumerators had to officially start working at a school on Monday; therefore, they could only give instructions on Monday at the earliest, so children started recording their consumption on Tuesday. We did not want to ask children to do recall of Monday as it induces recall bias, which we wanted to avoid in the first place by using diaries; and

Subject	Outcome Measure	Data collection Method
		- Consumption on consecutive days is known to be correlated. Vietnamese meals on Monday are in particularly highly positively correlated with the weekend when they usually have bigger, more nutritious meals. While school consumption was observed and recorded by enumerators, to measure at-home consumption, children were instructed by enumerators to fill in the home food diary at home themselves (with the parents' help if necessary). The paper diaries also provide written instructions, as well as pictures of common units of measurements to support respondent's recording. These units are excerpted from the Photographic Atlas of Food Portion Sizes in Viet Nam developed by NIN, which had been used in previous 24-hour recall surveys in the same district. The enumerators checked the completion of the food diaries before leaving the school. This check was done with the aid of a full version of the Photographic Atlas of Food Portions Sizes in Viet Nam.
Parent	Knowledge and attitude about fruits and vegetables	Corresponding parents of sampled children in both treatment and control groups were interviewed over the phone by trained callers. The parents had been informed in advance by the class teachers that researchers would contact them via phone numbers as they received the consent forms. The phone numbers were obtained from the school, and double checked with the children as they were interviewed to limit missed parents.
	Home consumption	The parents were also sent food diaries with the same format as those for their children. They returned the food diaries to the enumerators, who checked for consistencies and could ask for clarifications by phone.

Subject	Outcome Measure	Data collection Method
	Auxiliary data: - Household key demographics (age and gender of household head, household size, income level, etc.) - Child-parent communication frequency - Parental control over children's food choices - Self-assessment if respondent is eating sufficient fruit and vegetables	The auxiliary data was collected from personal interviews with the children and phone calls with their parents. The questionnaires for parents and children are included in the Appendix.
	Details of children's close friends from another grade	To estimate the extent of spillover, in the baseline, we asked the children if they have close friends that they frequently interact with from other grades. Close friends of the treated children were also interviewed at endline to investigate if their FAV consumption also changes.
	Compliance check: if children indeed tell their parents about what they learn in school	The children were requested to obtain a parents' signature to confirm their children have shared the materials. Parents of treated children were also asked if they have received materials from the school during phone interviews.

Appendix C: Questionnaire and Food Diary for children

ENDLINE QUESTIONNAIRE - CHILDREN

Improving Diets in Schools in Vietnam

Date of interview		
	Full name	Code
Commune		
School		
Grade		
Class		
Child (Full name)		
Sex of child		1. Male 2. Female
Parent/Caretaker (Full name)		
Enumerator (Full name)		

Section 1. Knowledge of fruit and vegetable	
1. Which of the following are true?	1. Fiber gives energy for the body 2. FAV help prevent constipation 3. Eating fruits brings about more health benefits than eating vegetables 4. FAV can provide all the nutrients that the body requires
2. Which of the following is/are true about orange, red and yellow FAV?	1. All of them are full of protein 2. They can boost your immunity 3. They can help lower the risks of heart- related diseases 4. They can help our bodies heal faster 5. We need to eat at least 5 portions of orange, red and yellow FAV per day 6. They usually contain high amounts of beta-carotene
3. TRUE OR FALSE: Leafy green vegetables usually contain vitamin C, iron and calcium, which helps immunity and bone development	1. True 2. False 99. Don't know

4. FAV of which colour can help you reduce tiredness/ fatigue?	1. Red 2. White/brown 3. Purple 4. Green 5. Yellow 99. Don't know
5. What are the health benefits of FAV with purple colour? (*Do not show the options, respondents can choose more than one answer*)	1. Boost energy 2. Help the working of the immune system 3. Make bones strong 4. Good for eyesight 5. Help the body grow 6. Help wounds heal faster 7. Improve memory 90. Others (Specify)
6. According to recommendation of health experts, a child your age should eat at least how much vegetable every day?	1. One cucumber and one tomato or equivalent (Figure 1) 2. Half a cucumber and half a tomato or equivalent (Figure 2) 3. One small bowl of boiled leafy green vegetable or equivalent (Figure 3)
7. According to recommendation of health experts, a child your age should eat at least how much fruit every day?	1. One banana and one segment of pomelo or equivalent (Figure 1) 2. One banana or equivalent (Figure 2) 3. One banana, one segment of pomelo, and one piece of dragon fruit or equivalent (Figure 3)
8. Endline 1: Tu likes pumpkin and carrot very much. He eats these vegetables almost every day. He does not like and rarely eats green leafy vegetables. Do you think that is good? Endline 2: Nam eats very little vegetable: He never eats vegetable during lunch time and only a little bit during dinner. He eats a lot of fruit though. Do you think that's good?	1. Yes 2. No 99. I don't know
9. Which of the following figures do you think represent a balanced meal?	1. Figure 1 2. Figure 2 3. Figure 3

Section 2. Attitude towards fruit and vegetable	
10. What are the benefits of eating FAV for you? (Do not show the options/read the list)	1. To be active/enjoy sports for a long time 2. To look good: e.g. have good skin and good hair 3. To feel energized 4. To concentrate well 5. To grow big and tall/ have strong bones 6. To prevent constipation 7. Help reduce/gain weight 8. To boost the immune system and fight diseases 9. To have better eyesight 99. Don't know 90. Others (specify)
11. How difficult is it for you to eat FAV?	1. Very difficult 2. Difficult 3. Neither easy nor difficult >> Q13 4. Easy >> Q13 5. Very easy >> Q13
12. Why do you think it is difficult to eat enough FAV?	1. FAV do not taste nice 2. I am not given enough FAV to eat at home 3. I am not given enough FAV to eat at school 4. FAV served at school are not clean 5. They are Ok, but there are many other tastier options 6. Others (specify)
13. It is estimated that the majority of Vietnamese do not eat enough FAV. Do you think you are eating enough FAV as recommended by doctors?	1. Yes 2. No 3. Don't know/ Not sure
14. Do you want to increase your intake of FAV	1. Yes, very much 2. Yes 3. No
Section 3. Practice of eating fruit and vegetable	
15. During the past 7 days, how many times did you eat fruit (do not count fruit juice)?	1. I did not during the past 7 days 2. 1 to 3 times during the past 7 days 3. 4 to 6 times during the past 7 days 4. 1 time per day 5. 2 times per day 6. 3 times per day 7. 4 or more times per day
16. During the past 7 days, how many times did you drink fresh fruit juice (do not count Fanta, vinajuice or other fruit flavoured drinks)?	
17. During the past 7 days, how many times did you eat green vegetables?	
18. During the past 7 days, how many times did you eat red vegetables?	
19. During the past 7 days, how many times did you eat orange and yellow vegetables?	

20. During the past 7 days, how many times did you eat purple vegetables?	
21. During the past 7 days, how many times did you eat white/brown vegetables?	
22. Do you often bring snacks to school to eat during break times?	1. Yes 2. No >> Q32
23. What types of snack do you often bring? (select up to 3)	1. Milk (sweetened) 2. Milk (unsweetened) 3. Biscuits/cookies 4. Cakes 5. Fruits (fresh) 6. Fruits (dried) 7. Juice (fresh) 8. Juice (packaged) 9. Nuts 10. Crisps (“bimbim”) 11. Sweets 12. Bread 13. Sticky rice 14. Ice-cream 15. Sausage 16. Fizzy drinks 17. Yoghurt (sweetened) 18. Yoghurt (unsweetened) 19. Instant noodle 90. Others (specify)
24. During school days, do you often have snacks at home after school?	1. Everyday 2. 3 – 4 days/ week 3. 1 – 2 days/ week 4. No >> Q34
25. What types of snack do you often have at home? (select up to 3)	1. Milk (sweetened) 2. Milk (unsweetened) 3. Biscuits/cookies 4. Cakes 5. Fruits (fresh) 6. Fruits (dried) 7. Juice (fresh) 8. Juice (packaged) 9. Nuts 10. Crisps (“bimbim”)

	11. Sweets 12. Bread 13. Sticky rice 14. Ice-cream 15. Sausage 16. Fizzy drinks 17. Yoghurt (sweetened) 18. Yoghurt (unsweetened) 19. Instant noodle 90. Others (specify)
Section 4. Perception of the project (for the treatment group only)	
26. Have you been taught about FAV in the last few weeks?	1. Yes >> Q27 2. No >> End of questionnaire
27. What topics were you taught? (*do not read/show the options, respondents can choose more than one answer*)	1. Balanced meal 2. Recommended amount of FAV intake 3. Benefits of FAV 4. How to increase FAV in meals 90. Others (specify) 99. Don't remember
28. In the lessons you have learnt about [the 4 topics above]. Which topic did you find most interesting? (*only choose 1 answer*)	1. Balanced meal 2. Recommended amount of FAV intake 3. Benefits of FAV 4. How to increase FAV in meals 5. I did not like any of the topics 90. Others (specify)
29. Please state one particular knowledge/ information that you take away from the lessons on FAV at school? (*do not read/show the options*)	1. We need to eat at least 2 portions of vegetables and three portions of fruits per day. 2. We need to eat FAV of a variety of colours namely green, purple, red, orange/yellow, white/brown. 3. Eating FAV helps us stay healthy, boost our immunity and memory, reduce risks of heart diseases and obesity etc.

	4. A balanced meal needs to include four groups of food namely carbohydrates (rice, noodles, bread etc.), protein (meat, fish, egg, dairy etc.), fiber and vitamin from FAV. 5. To eat more FAV we can try the 'take at least one bite' rule. 6. We should replace sweet snacks with ripe fruits and fizzy drinks/milk tea with fresh fruit juice. 90. Others (specify)
30. Do you feel you have eaten more FAV after the lessons on FAV at school?	1. Yes, a lot more 2. Yes, a little bit more 3. No
31. How do you rate the materials (leaflets, posters) used in the lessons on FAV on a scale from 1 to 5 regarding the following criteria?	31a. Easy to understand 31b. Attractively presented 31c. Easy to apply

END OF INTERVIEW. THANK YOU FOR TAKING PART IN THE SURVEY!

FOOD DIARY – CHILDREN

This diary belongs to: ……

Code

Commune		
School		
Grade		
Class		

Please complete the diary on the following days:

Day 1:

Day 2:

Day 3:

If you have any question, please contact ……

EXAMPLE

Meal	**Location**	**Food/drink**	**Description**	**Quantity**
Breakfast Time: 7.30am	ý at home □ school/day-care □friends/family □ restaurant etc. □ other, namely…	A small bowl of Phở Yoghurt	Rice noodles, beef, fresh herbs Vinamilk sweetened plain yoghurt	1 small-sized bowl (picture D) 100 grams
Morning snacks Time: 10am	□ at home ý school/day-care □ friends/family □ restaurant etc. □ other, namely…	Banana	"Tiêu" banana	1/2 medium-sized banana
Lunch Time: 11:30am	□ at home ý school/day-care □ friends/family □ restaurant etc. □ other, namely…	Rice Fried morning glory Steamed pork meatballs Fried tofu Thin soup with pak choy	Cooked white rice With some garlic Lean meat With some onions	2 small sized bowl (picture D) 2 spoons (picture A) 2 spoons (picture A) 2 small pieces ½ small bowl (picture D)

Meal	Location	Food/drink	Description	Quantity
Afternoon snacks Time: 4pm	□ at home **□ school/day-care** □ friends/family restaurant etc. □ other, namely…	Vinamilk sweetened milk Tangerine		1 carton box of 200ml 3 small tangerines
Dinner Time: 6pm	□ at home **□ school/day-care** □ friends/family restaurant etc. □ □ other, namely…	Rice Steamed carp Thin soup with carrots and mushrooms Pig ear salads with lettuce Chè (Vietnamese sweetened dessert)		2 small bowls ¼ of the carp Half a bowl Half a bowl 1 cup (200 ml)
Supper Time:	□ at home □ school/day-care □ friends/family restaurant etc. □ □ other, namely…	No supper		

Did you take any vitamins, minerals or other food supplements today?

Yes □ No □

If yes, please describe the supplements you took:

1 capsule of vitamin C 1000mg

Other comments: I ate a bit less today because I felt sick.

YOUR OWN DIARY STARTS IN THE NEXT PAGE

DAY 1: ...../2019

Meal	Location	Food/drink	Description	Quantity
Breakfast Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Morning snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Lunch Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

Meal	Location	Food/drink	Description	Quantity
Afternoon snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Dinner Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Supper Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

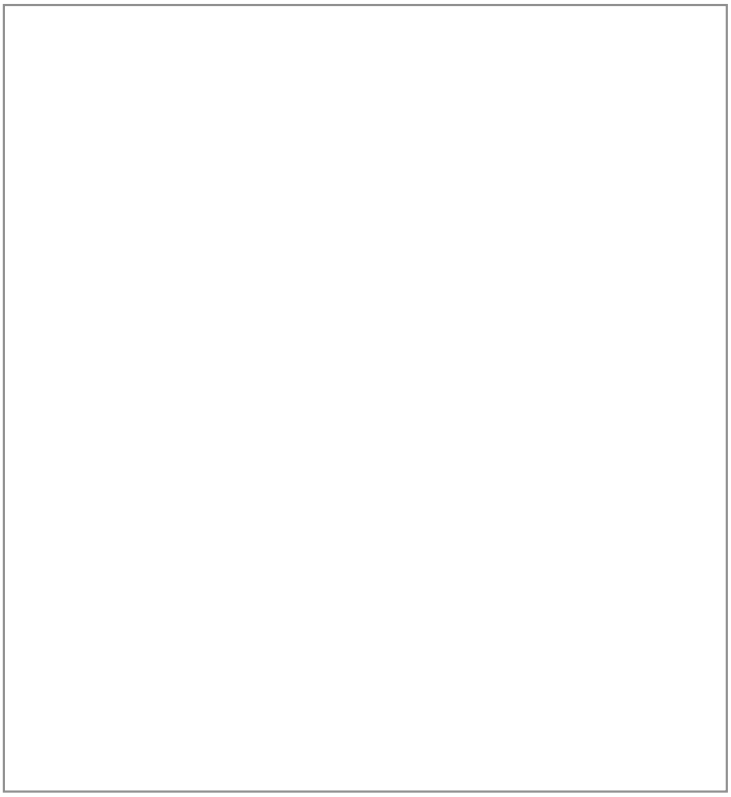
Did you take any vitamins, minerals or other food supplements today?

Yes □ No □

If yes, please describe the supplements you took:

Other comments:

You can use this space to draw the foods and drinks you have eaten J



DAY 2: ...../2019

Meal	Location	Food/drink	Description	Quantity
Breakfast Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Morning snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Lunch Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

Meal	Location	Food/drink	Description	Quantity
Afternoon snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Dinner Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Supper Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

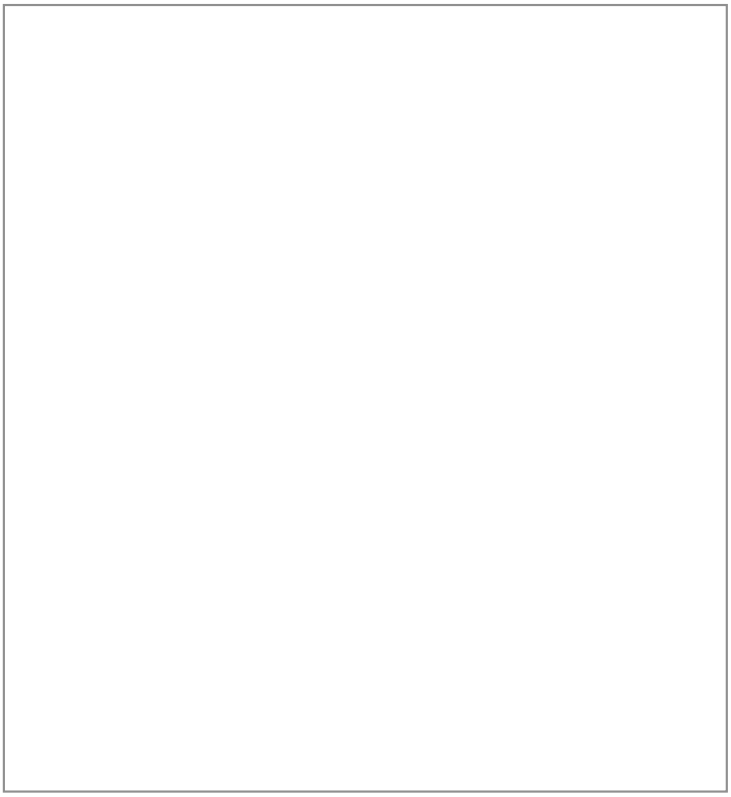
Did you take any vitamins, minerals or other food supplements today?

Yes □ No □

If yes, please describe the supplements you took:

Other comments:

You can use this space to draw the foods and drinks you have eaten J



DAY 3: ...../2019

Meal	**Location**	**Food/drink**	**Description**	**Quantity**
Breakfast Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Morning snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Lunch Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

Meal	Location	Food/drink	Description	Quantity
Afternoon snacks Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Dinner Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			
Supper Time:	□ at home □ school/day-care □ friends/family □ restaurant etc. □ other, namely…			

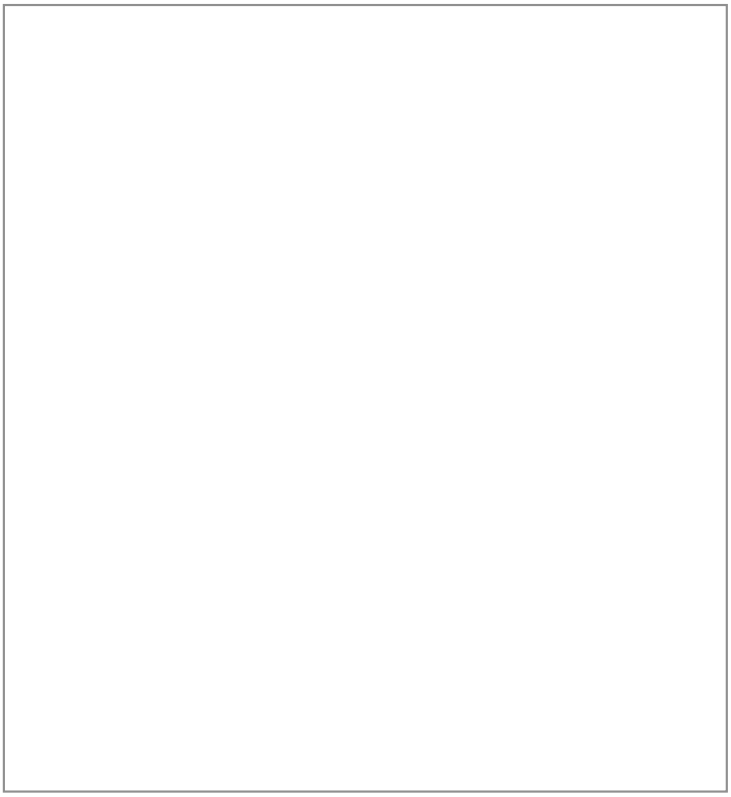
Did you take any vitamins, minerals or other food supplements today?

Yes □ No □

If yes, please describe the supplements you took:

Other comments:

You can use this space to draw the foods and drinks you have eaten J



Please look after your food diary

It is important that you bring it back to school on the next school day

Thank you for completing the food diary, we hope that you had fun completing it!

Instructions for completing a 3-day food diary

General guidelines

- This food diary is intended for use by:
  - Research assistants to record children's food consumption during lunch time and snacks at school
  - Parents to record children's food consumption at home
  - Children to record their consumption of foods not observed by research assistants/parents
- This food diary is to record **everything** the child ate and drank on the days noted on the front page (the latter day should also be clearly dated). Only the food consumption of the child that was given the diary and named on the diary should be filled in, not that of any other family members.
- If on the day selected the child has an unusual food intake due to an unusual event such as a party or illness, you should still record the **actual** food intake and take note of this under "Other comments".
- Record every bite or sip consumed and ensure to include all small items, e.g. small bites of an apple or cake, little sweets, water consumed etc.
- The day starts when the child rises in the morning of the day mentioned on the front page and ends when the child rises the next morning (so a complete day and night is monitored).
- The diary is structured for 6 eating periods: breakfast, during the morning, lunch, during the afternoon, evening meal, during the evening and night.
- If dessert is eaten together with the main meal (dinner or lunch), please include them in the respective meal.

Specific notes to parents

- Do not adjust the food intake of the child. Parents should feed the child as they would have done without a diary, and the child should eat like he/she normally eats.
- Try to fill in the diary immediately after the child consumes any food or drink. This will make omission of consumed foods less likely.
- If your child is away from you during any part of the diary day (day-care, school, family etc.), and the research assistant is not able to observe the child at these moments (e.g. your child eats out of school), please ask the child for details of food and drink consumed and fill it in yourself. Your child can also assist in filling in the booklet.

What do we ask you to record?

- If nothing was consumed during an eating period, you can write "None", and go on to the next eating period.

- During any eating period, we ask that you record:

- The starting **time** of the consumption. If the child eats the meal in several intervals (e.g. several afternoon snacks), if there is a break of 15 minutes or more between these, you should write all these separate times).
- The **location** of consumption. If the location differs from the categories specified in the diary (at home, school, friends/family, restaurant etc.), you can tick "other" and describe the location on the dotted line. "Restaurant etc." includes snack bar, cafeteria, fast food restaurant, street food stalls, self-service restaurant, bar, café, etc.
- The name of the **food or drink** (column "food or drink"), followed by a **further description** of the exact type of the food (column "description of food or drink").

- The **quantity** consumed. You can describe the **quantity** the child consumed whichever way you find most convenient. There are different methods:
  - Using the picture book you received and writing down the picture number and letter.
  - In grams or ml if this is mentioned on the package.
  - In natural units, e.g. a slice of bread, a piece of fruit, etc.
  - In household measures, e.g. glasses, cups, bowls etc., or in different types of spoons (tablespoons, teaspoons etc.)
- In the column "**description of food or drink**" you are asked to further describe the exact type of the food or drink. Please describe the food extensively:
  - For packaged foods and drinks, whenever possible, the following descriptions should be included: The full product name: brand name, product type or flavor, specification on the composition: low-fat, skimmed; sweetened with sugar or with artificial sweeteners; with added vitamins and/or minerals; light, etc., preservation method: fresh, deep-frozen, canned, dried, pasteurized, etc.
  - For any home-prepared meals, you are also asked to describe the preparation method in this column, for instance boiled, fried, stir-fried, microwaved etc. Whenever possible, the recipes should be described in as many details as possible: ingredients used (including cooking fat) as per the headings given and the quantity of each ingredient.
- In the column "quantity consumed" you should fill in the **actual quantity consumed** by the child. So, if the child is served a whole glass of milk, but he/she drank only half of it, you would fill in ½ glass.
- **Dietary supplements:** At the end of the diary, you can mention if the child took any vitamins, minerals or other dietary supplements on this day. If applicable, give a full description of the supplement(s), and fill in the quantity consumed.

- **Comments:** There is open space for comments. Please tell us if anything is unusual about your diets in the 2 days of diary (e.g. you were sick, you had a big dinner because it was your birthday, you ate more cakes because the class had a party, etc.). You can also use this page if you lack space in any other part of the diary.

Common food measuring tools:

Small Bowl

A (220 ml)

B (220 ml)

C (250 ml)

D (250 ml)

E (250 ml)

F (300 ml)

G (200 ml)

H (400 ml)

Rice example

½ bowl 250 ml: 90g

2/3 bowl 250 ml: 150g

1/3 bowl 300 ml: 64g

½ bowl 200 ml: 60g

Sticky Rice

½ bowl 250 ml: 120g

Full bowl 250 ml: 200 g

Stir fry potatoes

½ bowl 220 ml: 110g

Boiled morning glory

2/3 bowl 220 ml: 102g

Malabar spinach

½ bowl 250 ml: 74g

82 g

Katuk

½ bowl 220ml: 52g

Stir fried green bean

2/3 bowl 220 ml: 110g

Stir fried chayote

½ bowl 220 ml: 84g

Pumpkin

2/3 bowl 220 ml: 144g

Big Bowl

A (500 ml)

B (500 ml)

C (500 ml)

D (500 ml)

Weight of some food in big bowl:

Rice noodle

½ 500 ml bowl: 138 g

½ 500 ml bowl: 114g

Porridge

½ 500 ml bowl: 270g

½ inox bowl 500 ml: 258g

Plastic mugs

E (200 ml)

F (200 ml)

G (300 ml)

H (130 ml)

Glass

A (220 ml)

B (250 ml)

C (180 ml)

D (200 ml)

G (350 ml)

H (130 ml)

Weight of some drinks in glass:

200 ml glass: 80 ml orange juice

250 ml glass: 180 ml mango smoothie

Spoon

A (12 ml)

B (12 ml)

C (5 ml)

D (3 ml)

E (15 ml)

F (10 ml)

Weight of some food in spoon

26 g stir fried potatoes (spoon 12 ml)

22 g minced pork (spoon 12 ml)

10 g katuk (spoon 12 ml)

22 g cabbage (spoon 12 ml)

28 g stir fried chayote (spoon 12 ml)

24 g stir fried pumpkin (spoon 12ml)

Measuring unit and weight of some common fruits

Pomelo segment 11x4x2 cm(76g), 8.2x4.5x2.8 cm (56 g)

Big side of a mango (13.5x8 cm) (172g), small side of a mango (76g)

Jujube 6.3x5cm (90g), 5.7x4cm (68g)

Guava 8,3x8,7cm (352g), a wedge of guava (7,8x2cm) (28g)

Green orange 7,5x8,7 cm (286g)

Yellow orange to 8,2x8,2cm

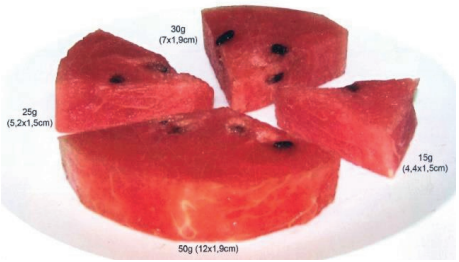
(250g)

Mandarin 5x6cm (104g), a segment of mandarin 10g

Pear 6.9x6.9cm (186g)

Banana 17x3.2cm (120g)

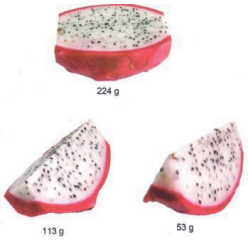
Pisang Awak 13x3.8cm(126g)



Pieces of watermelon in different sizes

Apple 6.3x7cm(144g)

¼ apple 36g



Wedges of dragon fruit in different sizes 14x8.7cm

¼ pineapple 7x6.3cm (55g)

Pineapple 12.2x9.5 (560g)

Bunch of grapes 126g

Some processed food

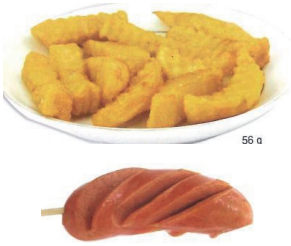
Roll cake 6.5x3.5cm(87g)

Merino ice cream (90g)

Mixed sweet dessert 209g, sweet black bean soup s227g

Biscuit 4x5cm (4g)

lollypop 12g



Potato wedges 56g

Fried sausage 50g

Bimbim Poca 27g

Chocopie 30g

Steamed pork bun 10.3x5cm (116g)

Steamed roll cake 198g, Vietnamese pork sausage18g

Appendix D: Additional results for treatment effects on parents

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS with control variables			2SLS, with treatment instrumenting for compliance		
VARIABLES	Knowledge index	Attitude index	FAV consumption frequency	Knowledge index	Attitude index	FAV consumption frequency
Nutrition lessons	-0.05	-0.06	1.31	-0.13	-0.24	3.94*
	(0.07)	(0.10)	(0.88)	(0.16)	(0.25)	(2.12)
Male child	-0.05	-0.07	-0.94***	-	-	-
	(0.06)	(0.05)	(0.29)			
Age	0.05	0.08	-0.10	-	-	-
	(0.05)	(0.06)	(0.52)			
Household income quartile = 2	0.10	-0.18**	0.81	-	-	-
	(0.08)	(0.08)	(0.54)	-	-	-
Household income quartile = 3	0.16**	-0.17**	2.20***			
	(0.07)	(0.07)	(0.42)	-	-	-
Household income quartile = 4	0.24***	-0.11	2.27***			
	(0.07)	(0.07)	(0.51)	-	-	-
Household size	0.02	-0.01	-0.04			
	(0.02)	(0.02)	(0.20)			
Male parent	-0.04	-0.01	-0.26	-	-	-
	(0.07)	(0.06)	(0.72)			
Baseline value	0.29***	0.29***	0.18***			
	(0.03)	(0.03)	(0.03)			
Constant	-0.63	-0.58	23.68***	0.00	0.00	24.46***
	(0.49)	(0.58)	(5.27)	(0.05)	(0.08)	(0.73)
Observations	1,308	1,308	1,308	1,340	1,340	1,340

Cluster standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 5

Nudging towards Healthier Food Choice for Children

Using information and cognitive dissonance

Abstract

It is of public health interest to nudge children towards healthier food choices such as beverages with less sugar. We conducted a field experiment in peri-urban Viet Nam to evaluate the effects of information and cognitive dissonance arousal on children's food choice. Over 1200 primary school children were randomly assigned into three groups: control, health information, and health information plus hypocrisy inducement – a way to raise cognitive dissonance by illustrating the gap between what people know they should do (socially desired behaviors) and what they actually did (transgressions). We found that health information raised the likelihood of selecting milk with less sugar by around 30% compared with the control group. Hypocrisy inducement did not have additional contribution to healthier food choice in our sample. The treatment effects declined with the delay between the treatment and behavioral choice. We discussed the practical implications of our findings for short-term intervention field studies.

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5.1. Introduction

Poor choices about what foods to consume can lead to detrimental health consequences. Increased risks of non-communicable diseases (NCDs), which are on the rise throughout the world, including low and middle income countries (LMICs), have been linked to unhealthy diets (Popkin, 2003; Matthew Kelly, 2016). Excessive consumption of sugar, especially from sugar-sweetened beverages, has been associated with dental caries, metabolic syndrome, type 2 diabetes and weight gain (Morenga et al., 2013; Le Bodo et al., 2015; Khan & Sievenpiper, 2016). Leading organizations such as the World Health Organization recommend reducing added sugar in diets, to mitigate the risk of NCDs in adults and children, particularly to prevent and control unhealthy weight gain and dental caries (World Health Organization, 2015).

In Viet Nam, the high consumption of foods high in sugar and calories has been blamed for the rise of overweight and obesity among children. A recent study by the National Institute of Nutrition found that 42 percent of children in Viet Nam's urban areas are overweight and/or obese, relative to 35 percent in rural areas (An, 2019). The same study also stated Vietnamese students tend to pursue unhealthy food habits such as consuming sugary drinks and sweet food products. In 2018, in aggregate Viet Nam consumed about 46.5 grams of free sugar every day per capita. This amount is close to the maximum daily intake of 50 grams and almost double the recommended daily intake of under 25 grams by the World Health Organization for an individual (Anh, 2018). How to steer children's choice towards healthier options, such as foods and drinks with less added sugar, is an important question for schools and families.

Behavioral economists have introduced nudges as a potentially powerful and increasingly trusted public policy tool to improve people's behavior, including eating more healthily (Thaler & Sunstein, 2008; Bauer & Reisch, 2019; Sunstein et al., 2019). For example, activating health goals at the moment when decisions are being made has been found to help people overcome impulsive unhealthy food decisions (Wilson et al., 2016). Other research has manipulated social norms, such as health messages about others' behavior, to implement interventions that induced people to eat healthier foods (Robinson, 2013). To overcome the misjudgment of long-term costs and short-term benefits in making health-related decisions, researchers have also attempted to link healthier choice with immediate rewards. Among younger consumers, incentives have been a popular medium to steer children towards healthier choices. Belot et al. (2016) found that competition boosted the effectiveness of in-kind rewards in encouraging

children to eat more fruit and vegetable at lunchtime, while List and Samek (2015) found that gain versus loss framing did not make a difference in incentivizing children to select healthier snacks.

It has been acknowledged that cognitive dissonance theory can be a useful behaviorial tool in changing food-related attitudes and food choices (Worsley, 2002; Ong et al., 2017). Cognitive dissonance relates to the internal discomfort people feel when their beliefs, emotions, attitudes and actions enter into contradiction with one another. People are then motivated to reduce this tension by adjusting their beliefs or actions. Arousing dissonance can therefore be used to achieve behavioral changes. While multiple behavioral science concepts have been tested and successfully scaled up, the study of cognitive dissonance related to eating attitudes and behaviors in the food and nutrition domain is relatively underdeveloped. There exists a lack of research that tries to use cognitive dissonance to influence healthy food behaviors (Ong et al., 2017). Empirical evidence has shown the effectiveness of this approach in studies related to changing behaviors towards socially desirable ends such as water use reduction (Dickerson et al., 1992), condom use (E. Aronson et al., 1991), charitable giving (Kessler & Milkman, 2018) and reducing hypothetical bias in contingent valuation studies (Alfnes et al., 2010).

Inducing hypocrisy is among the major paradigms associated with cognitive dissonance arousal. The "hypocrisy" paradigm involves two steps to arouse cognitive dissonance: individuals are induced to make public statements consistent with normative standards, and then reminded of times when they did not act in accordance with such standards. Individuals are consequently nudged to resolve this dissonance by taking the correct actions. A recent meta-analysis supports that hypocrisy induction has a moderate positive effect on both behavioral intention and behavior (Priolo et al., 2019). This review only included one study on children (Morrongiello and Mark, 2008). We tested if this "hypocrisy" condition nudges children towards choosing healthier foods for their snacks in a lab-in-the-field experiment in Viet Nam.

Our pre-registered experiment took place in 12 primary schools in peri-urban Hanoi, Viet Nam[28]. We randomly assigned 136 classrooms to one of three experimental conditions:

[28] Registration number 20191201AA on the egap.org Registry. The study was approved by the Internal Review Board of IFPRI and Hanoi School of Public Health Institutional Review Board (HSPHIRB), Viet Nam.

Control, an information treatment, and an information plus hypocrisy inducement treatment. 10 randomly selected children from each classroom participated in the experiment. In the first treatment, the children watched a short animation about healthier eating. In the second treatment, after watching the short animation, the children were asked to record a message about eating less sugar to share with others and reminded of their actual sugar eating habits. This procedure, so-called hypocrisy inducement, intended to induce children to realize they are not practicing what they are preaching. At the end of the experiment, we offered milk cartons as thank-you gifts for all participating children. They could choose among three options: Sweetened milk, reduced sugar milk and unsweetened milk. We recorded this choice of milk as an outcome measure for healthier eating behavior.

Our study makes three contributions to the behavioral health economics literature. First, we evaluate whether the dissonance arousal nudge improves the use of an information provision nudge. While providing information is a cheap and scalable approach, the evidence regarding its effectiveness in behavior change has been mixed (Bauer & Reisch, 2019). In fact, educational messages have failed to influence behavior in several studies on food choice (List & Samek, 2015; List et al., 2015). Our experiment adds a hypocrisy inducing procedure to the information-provision condition and compares it with the information only condition. In studies using a hypocrisy paradigm to motivate good behavior among younger subjects, information was embedded in the activities. In Morrongiello and Mark (2008), sampled children aged 7-12 viewed a poster about safe play on the playground before being asked to sign the poster and say the message headings on a radio commercial. In Ager et al. (2008), a group of 10 to 12-year-old children participated in weekly sessions on video skills and substance abuse. It was not clear if hypocrisy played a fundamental role or the educational aspect or the information mattered most. Second, to our knowledge, we run the first experiment on children's food choice using a dissonance arousal nudge. Previous research has used the same tactic to successfully prevent children from other harmful behaviors, e.g. risky behavior on the playground (Morrongiello & Mark, 2008) or substance abuse (Ager et al., 2008). Third, our research adds to the nascent body of experimental work on children's food choice, especially in LMICs. The majority of publications on school-based food choice experiments have been in the developed countries, such as the United States and European countries. In a recent review of experimental research on children's eating behavior by

DeCosta et al. (2017), only 2 of the 120 studies mentioned were conducted in LMICs. Like in many LMICs undergoing the nutrition transition, Viet Nam's National Nutrition Strategy has put school nutrition education and overweight/obesity/NCDs control as key target projects to fulfill the strategy's objectives. Our findings can provide valuable inputs for this strategy whose lessons can then be applied in other developing country contexts.

The remainder of the paper is structured as follows: Section 5.2 provides the conceptual frameworks and motivates our hypotheses, Section 5.3 outlines the experimental design, including treatment descriptions, Section 5.4 presents the findings and Section 5.5 provides discussions and conclusions.

5.2. Conceptual framework

Information provision

Children's consumption is driven partially by their beliefs about whether consuming specific foods, for instance those with added sugar, can be beneficial, neutral or harmful to them. If we assume children have a predilection for sweetened foods, their consumption of healthier options like unsweetened and reduced sugar milk can be considered a function of their effort to overcome that partiality and a set of predetermined characteristics (Avitabile & de Hoyos, 2018). Providing health information can help them update their beliefs regarding the costs of consuming sweetened foods, including risks associated with excessive consumption, and updating those beliefs may lead children to opt for a healthier option. As consumers usually do not have full information about calories and nutrients at the point of consumption (Cawley, 2015), information provision can also be thought of as an initiative to correct imperfect information among consumers. Although nutrition education is part of the school's curriculum, the knowledge conveyed is usually generic and abstract, making it hard for children to relate it to their daily food choices. In this research, we used a quick educational message directly related to the targeted behavior of choosing healthier milk to nudge children towards selecting better food.

Evidence on the use of quick educational messages to affect food choice of children in the school environment has been mixed. For example, in a field experiment on low-income school children in the US, short educational messages delivered by research assistants alone, without explicitly prompting the child to choose the healthier option, had no effect on dessert choice

(List & Samek, 2015). A more recent experiment on similar subjects observed a positive impact of health information messages from teachers in driving student behavior when choosing milk (Samek, 2019). In comparison with List and Samek (2015), this positive result was explained by the fact that the educational message was delivered by an authority figure (the teacher). How the educational message is delivered can play an important role in the efficacy of such an intervention. Meanwhile, Lai et al. (2017) found that prescriptive prompts, which involved telling children to choose healthier options, either with or without health messaging, increased the proportion of children choosing and consuming healthier white milk relative to sugar-sweetened chocolate milk from 20% in the control group to 30% in the treatment groups.

In both of our treatment groups, children watched a short educational video about healthy food choices. The video messages covered not only the consequences of eating excessive sugar (informative messaging), but also practical suggestions to reduce consumption of added sugar (prescriptive messaging). It was produced in a child-friendly manner with lively animation and colors, similarly to how a social marketing video was prepared, with a spokes-character, the predominant marketing technique (Elliott & Truman, 2019). We therefore predict that relative to the control group, more children in both of our treatment groups would opt for healthier food options. Therefore, our first hypothesis is:

Hypothesis 1: The provision of information decreases the likelihood of children choosing fully sweetened milk.

Cognitive dissonance and hypocrisy paradigm

The discrepancy between a cultural mores and a behavior arouses cognitive dissonance (Festinger, 1957). Individuals generally strive for consistency, competence, and morality in their perceptions of themselves, which results in psychological discomfort when they behave in a manner that negates these features (Elliot Aronson, 1992). Economic agents may incorporate these psychological costs into their utility maximization problems. Cognitive dissonance has been attributed to a range of social phenomena, such as increased level of immoral activities (Rabin, 1994) and stickiness in voting (Mullainathan & Washington, 2009).

Beyond explaining behaviors, cognitive dissonance has been manipulated by social scientists to cause behavior change through the use of different paradigms (Ong et al., 2017). Among the most frequently utilized, the induced hypocrisy paradigm was first developed by Aronson

et al. (1991). They designed a sequential procedure to achieve cognitive dissonance, by illustrating the gap between what a person knows he or she should do in a certain situation (socially desired behaviors) and what he or she actually did (transgressions). To make this gap salient and cognitive dissonance most effective, people should be requested to publicly advocate the value of a target behavior (step one) and privately reminded of their own recent personal failures to perform that behavior (step two). This state of dissonance can be reduced by changing behavior, which has been demonstrated in a range of empirical evidence that shows how cognitive dissonance leads to behavior change (Gosnell, 2018). Cognitive dissonance does not only apply to adults. Evidence of decision rationalization due to cognitive dissonance has been documented in preschoolers and nonhuman primates (Egan et al., 2007), and inducing hypocrisy has been successfully applied on children (Morrongiello & Mark, 2008; Ager et al., 2008).

Nevertheless, hypocrisy inducement does not always bring about behavior change. When faced with cognitive dissonance, a change in behavior is not guaranteed, as people can also change their attitude and belief (Rabin, 1994; Akerlof & Dickens, 2009). Participants can resolve cognitive dissonance by various reduction modes, which they can choose one over another. For example, participants can adjust their attitude or behavior, depending on such mode's characteristics, for example the availability, likelihood of success, effortfulness and habits (McGrath, 2017). In a field experiment on cognitive dissonance and environmental behavior, the hypocrisy inducing messaging did not work for some individuals with higher education. Their higher cognitive skill possibly determines the levels of experienced dissonance, which means the intervention did not do enough to trigger cognitive dissonance. Besides, instead of changing their behavior by switching to environmentally friendly billing, the individual could alter their attitude towards the issue as a way to justify their socially undesirable action – using traditional billing (Gosnell, 2018).

In our experiment, changing behavior would be the most accessible and effortless mode when children were offered the choice of milk immediately after the cognitive dissonance inducement treatment. In line with the evidence in the literature on hypocrisy inducement, we predict that children would be less likely to select sweetened milk in treatment group 2 "information provision plus induced hypocrisy" than in the treatment group 1 "information provision only". Similar to Gosnell (2018), we do not attempt to measure a "pure" effect of

hypocrisy inducement, but rather an "additional" effect of making cognitive dissonance particularly salient. Providing health messages may already play a role in creating cognitive dissonance, as the children are informed of the consequences, or "costs" of their unhealthy eating habit. Therefore, the second hypothesis can be stated as:

Hypothesis 2: Inducing "hypocrisy" increases the likelihood of selecting healthier food choice due to cognitive dissonance.

Timing and cognitive dissonance

In everyday contexts, people can experience cognitive dissonance without the possibility to reduce it immediately by performing the "good" behavior. This delay in reducing dissonance through actions might activate other modes of reduction, decreasing the influence on behavior. Rubens et al. (2015) conducted an experiment in a Parisian market to examine if cognitive dissonance caused participants to reduce plastic bag use. They found that the effects of the hypocrisy paradigm were sensitive to the delay existing between the intervention and the moment the behavior was observed, when the respondents in the hypocritical condition failed to pick up fewer plastic bags. Instead of changing towards environmental behavior, the participants had time to trivialize and rationalize their "bad" behavior.

Besides behavior change and trivialization, one very convenient strategy to reduce cognitive dissonance is via distraction and forgetting. These two modes allow individuals to divert their attention away from dissonant thoughts and avoid the negative affective state caused by dissonance (McGrath, 2017). Forgetting can be a method to avoid information (Golman et al., 2017). We are interested in exploring if the distraction and forgetting mode was picked up by our subjects – children are thought to be prone to distraction and forgetfulness. To do so, we vary the timing of the experimental procedure among our children, so one group was occupied with another task (answering a questionnaire related to a study on fruit and vegetable consumption) after watching the video but before making the food choice.

If children forget the information to reduce cognitive dissonance, the additional effect on behavior that the hypocrisy procedure causes (in addition to the educational treatment) will erode. Therefore, our third hypothesis is:

Hypothesis 3: When there is a delay between the intervention and the target behavior, children are equally likely to select healthier milk in treatment 2 compared to treatment 1.

Hypothesis 3 is closely related to hypothesis 2. If we reject hypothesis 2, which means hypocrisy inducement does not cause an additional effect, the delay will have a similar influence on the effects of both treatments. In this case, hypothesis 3 still holds, but the explanation that the treatment effect erodes due to activated dissonance resolution will no longer apply. Rather, the treatments effects may erode equally over time between both treatment groups due to lessened pressure from experimenter demand and distant memory of the provided information.

Hypothesis 4: When there is a delay between the intervention and the target behavior, children are less likely to select healthier milk in both treatment groups, compared to the no-delay condition.

5.3. Experimental Design

Participants and random assignment

Our sample for this experiment consists of 1,274 fourth and fifth graders from 136 classrooms of 12 schools in Dong Anh, Hanoi. The study ran in parallel with the second endline data collection for a randomized trial conducted at the end of the previous school year[29]. The fieldwork took 2 weeks to complete, with enumerators spending around 30 minutes with each child on the experiment. For this survey, the children answered a number of questions on fruit and vegetable consumption.

The treatment assignment was randomized at the classroom level. Randomization at this level helped minimize the diffusion of treatment as children from different classes were less likely to interact with each other, and we prevented interactions between children from different classes. Our experimental set-up (See Appendix 1) also helped eliminate peer effects within classes, by not letting children observe their peers' choices. We used grades (4-5) and schools

[29] The schools were pre-selected based on the requirements of an overarching research program (Agriculture for Healthier Diets (A4NH CGIAR) program in Vietnam). The children were also the subjects of a study titled "Improving diets in Vietnamese schools – Testing innovative methods to influence demand" under the same A4NH research program. We sampled 10 children from each of the 3-5 grade classrooms in all the 12 schools for data collection. Sampling design was detailed in Nguyen et al. (2021).

(1-12) as block strata in the random assignment. While grade was a proxy for age, school was a proxy for commune-level characteristics in our data. Our subjects were then assigned to 3 experimental groups: Control group (45 classes), Treatment 1 ("information only" treatment group) (46 classes) and Treatment 2 ("information and hypocrisy" treatment group) (45 classes).

Treatment descriptions

The detailed experimental procedure is included in Appendix 1. Experimental set-up and procedures. In summary, all participant children would answer a questionnaire, which included general questions about eating fruit and vegetables, and specific questions about their milk drinking habits. They also went through the "treatment" stage, which differed among the treatment groups. The key descriptions of the treatments are as follows:

- Control - "Placebo education": the students watched a placebo video about traffic safety.
- Treatment 1 - "Information only": the students watched a short animated educational video about cutting down sugar in their diet. The video included practical examples such as replacing flavored and sweetened milk with plain milk; eating natural rice crackers instead of honey flavored rice crackers; choosing bubble milk tea with less sugar. The video lasted 1 minute 15 seconds, using child-friendly animation to emphasize the harm of eating excessive sugar and the growing health standard of eating less sugar.
- Treatment 2 - "Information and hypocrisy". The children watched the same video as in treatment 1, and also went through a dissonance arousal procedure using the "hypocrisy paradigm" (Dickerson, Thibodeau, Aronson, & Miller, 1992; Gamma, Mai, & Loock, 2018). Following the video, each child was first asked to recite what they had learned. The enumerator recorded the message and told the child that the message would be sent to children in other schools to promote healthy eating. In a second step to induce dissonance, the child answered a brief set of simple questions about their habits with sweetened foods on a piece of paper.

Blocking delay

To vary the timing of the experimental procedure among our children, we divided the schools into two groups based on the data collection timeline. The data collection plan was arranged between the data collection team and each of the school principles. In the first half of the data

collection, for the first six schools, the children made a milk choice immediately after watching the video (and going through the hypocrisy procedure). In the second six schools (the "delay" group), the children were occupied with another task after seeing the video but before making the milk choice. This filler task involves answering the endline questionnaire of the school study, which took around 15 minutes.

Behavioral outcome

We used a simple choice between unsweetened milk, reduced sugar milk and sweetened milk as the outcome measure. Milk consumption is being promoted throughout Viet Nam as one means to raise the national population's dairy consumption. Packaged milk is a popular snack among children, both at school and at home. At home, 32% of the children in our sample drink sweetened milk as snack, while only 3% drink plain milk. The children are neither frequent consumers nor fans of healthier milk products. Only 15 percent of the sample cited healthier milk products with less sugar as the milk they most commonly consumed. Instead, sweetened milk, flavored milk and other sweetened non-dairy milks were consumed by 51.2%, 18.1% and 15.8% of the children, respectively. Our data also shows that sampled children had limited familiarity with healthier milk choices. Virtually all children (99.4%) drank sweetened milk, and more than half of them had never tried unsweetened (57%) or reduced sugar (59.9%) milk.

At school, under the school milk program, children have been provided with exclusively sweetened milk as "it suits the taste of the majority." To make initial steps towards reversing this unhealthy pattern, we offered children the choice to select healthier options and nudged them towards the healthier choice. As food safety is a huge concern in Viet Nam, we had to use branded milk cartons. We picked TH true Milk, as the packages are almost identical for the three milk types, ruling out the concern that children would select a certain milk due to attractive packaging, or because they did not want others to know what they had picked (Figure 11). The brand is not as common as other brands (e.g. Vinamilk, Nestle or Friesland Campina) so children were less likely to tell which flavor of milk their peers had chosen. During the pilot, we could ascertain that the children indeed selected the correct type of milk as per their preferences, despite the similar packaging.

***Figure 11**. Milk choices: unsweetened milk, reduced sugar milk, sweetened milk (from left to right). Source: thmik.vn*

Analytical model

Although we collected data at the child level and registered our analysis using individual level analysis, we decided to start with classroom level, a similar approach to that of Samek (2019). The author set the main outcome measure as the proportion of children choosing the healthier white milk in a classroom. We used a binary outcome for milk consumption at the child level: 0 for unhealthy option (full sugar milk) and 1 for one of the healthier options (reduced sugar or unsweetened milk). Converting this coding into a proportion at the class level makes interpretation of the results more intuitive. We could directly interpret the coefficients in the ordinary least square (OLS) regression as the effect of the treatments.

The OLS regression used the following specification, with the proportion of children choosing healthier milk as the dependent variable, relative to all children getting milk:

$$y_j = \beta_0 + \beta_1 I_j + \beta_2 IH_j + \beta_3 D_j + \beta_4 D_j I_j + \beta_5 D_j IH_j + \sum_{k=1}^{12} \alpha_k^1 S_k + \alpha_{13} G_4 + \alpha_{14} G_5 + \epsilon_j \quad (1)$$

Where y_j represents the percentage of children selecting healthier option (reduced sugar or unsweetened milk) class j.

The effect of the information treatment (I) (treatment 1) and information and hypocrisy (IH) (treatment 2) is given by β_1 & β_2, respectively. D_j is a dummy variable that indicates whether there is a delay between the intervention and the milk choice. $S_1 \dots S_{12}$ are school dummies and G_4 & G_5 are grade dummies, representing the stratum we included in random assignment.

The individual effect of the hypocrisy inducement procedure is $\beta_2 - \beta_1$ (plus the interaction between the information and hypocrisy).

As pre-registered, we estimated the effect of the information and hypocrisy treatment on the milk selection of children at the individual level by using the following formulation:

$$y_{ij} = \beta_0 + \beta_1 I_j + \beta_2 IH_j + \beta_3 D_j + \beta_4 D_j I_j + \beta_5 D_j IH_j + \sum_{k=1}^{12} \alpha_k S_k + \alpha_{13} G_4 + \alpha_{14} G_5 + X'_i + \epsilon_{ij} \quad (2)$$

In (2), the only difference with (1) is that y_{ij} represents the milk choice of the child i in class j. y_{ij} is a binary variable: 0 for unhealthy option (full sugar milk), 1 for healthier option (reduced sugar or unsweetened milk). X'_i is a vector of baseline covariates (controls), which includes demographic variables and "baseline" values of outcome variables for balance checks, heterogeneous effect and sensitivity analyses (Appendix Table 2).

The null hypotheses corresponding to our main hypotheses are:

$H_0 1$: $\beta_1 = 0, \beta_2 = 0$: Both treatments have no effect on children's food choice.

$H_0 2$: $\beta_1 = \beta_2$: hypocrisy inducement has no added effect on information.

$H_0 3$: $\beta_1 + \beta_4 = \beta_2 + \beta_5$: treatment 1 and 2 have a similar effect in the long run.

$H_0 4$: $\beta_4 = 0, \beta_5 = 0$: the effects of both treatments do not decline with the delay.

5.4. Results

Balance among treatment arms

We use two approaches to compare the characteristics of the treatment and control group. First, we did a series of pairwise t-tests comparing average values of those characteristics among Treatment 1, Treatment 2 and the Control group, using "baseline" milk consumption and demographic variables. The milk consumption variables came from the questionnaire and serves as our pseudo "baseline" before the experiment took place. The demographic variables for gender, household size and the household income level of the children came from the data of another study on the same subjects. Second, we conducted a joint test of orthogonality using a χ^2 test. We ran a multinomial logit with the treatment variable on the left-hand size, and milk consumption and demographic consumptions as explanatory variables on the right-

hand side. The null hypothesis is that all the regression coefficients across two models (for three treatment values) are simultaneously equal to zero.

The pairwise t-tests yielded only one variable "has tried reduced sugar milk" with a statistically significant difference between Treatment 1 and Control at the 5 percent level, out of 28 comparisons (Table 24). This table suggests randomization succeeded in generating balance among the treatment arms. The second approach came to a similar conclusion. With p-value > 0.05 (Prob > χ^2 = 0.12), we could not reject the null hypothesis, which implies that the three groups were similar on the explanatory variables (Appendix 3).

We used the same methods to check for balance between the group with delay and without delay between treatment and behavioral choice. We observed one notable imbalance between the two school groups. Compared with the "with delay" school group, the "without delay" group had a significantly higher percentage of children who had tried unsweetened milk before (48.26% vs 39.42%). Using joint orthogonality test, with p-value < 0.05 (Prob > χ2 = 0.002), we could reject the null hypothesis, which implies that the two groups were not similar on all the explanatory variables (Appendix 3). This slight imbalance is expected, given the fact that the delay was only randomized between two groups of schools. If we looked at the school-level statistics, the two school groups were balanced in terms of the average age and sex of the students, their milk consumption, and household size and income level (Table 24).

Table 24. *Balance check among treatment arms: Pairwise t-tests*

Variables	All		Control	Difference				
	Mean	St. Dev.		Treat 1 - Control	Treat 2 - Control	Treat 2 - Treat 1	Delay - No delay (child level)	Delay - No delay (school level)
Tried unsweetened milk before	0.43	0.50	0.42	0.001	0.014	0.007	0.088***	0.075
Tried sweetened milk before	0.99	0.08	1.00	-0.007	-0.004	0.002	0.004	0.005
Tried reduced sugar milk before	0.40	0.49	0.36	0.081**	0.027	-0.054	-0.016	-0.029
Male	0.56	0.50	0.55	0.002	0.023	0.021	-0.001	0.010
Household size	4.53	1.21	4.63	-0.126	-0.187	-0.061	-0.208***	0.207
Income level	2.37	1.17	2.44	-0.077	-0.153	-0.076	-0.117	0.059

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Main treatment effects

Classroom level analysis

The proportions of children choosing healthier milk were significantly higher in both treatment groups than in the control group. The proportion of children consuming healthier milk was significantly higher in Treatment 1 and Treatment 2, at 56.9% and 59.8%, respectively ($p < 0.0001$ for both Treatment 1 vs. Control and Treatment 2 vs. Control). Only 30.7% of control group children selected unsweetened or reduced sugar milk. Interestingly, this proportion was much higher than the frequency that healthier milk was reported as the most frequently consumed (15%) and favorite milk (16.1%) by the children before the treatment. The intra-cluster correlation was 0.13, lower than what we assumed in our pre-analysis plan (0.15) but still large enough to account for in our cluster randomization design. In treatment groups, about 35% of the classes mainly chose one type of milk (where more than 75% of the students in a class selected healthier or unhealthy milk).

Table 25 reports the regression results. Treatment 1 and Treatment 2 raised the proportion of children selecting healthier milk by 38.3 percentage points and 36.7 percentage points, respectively. We therefore reject H01 and conclude that the provision of information decreases the likelihood of children choosing full sugar milk, with or without hypocrisy inducement.

Regarding Hypothesis 2, we do not detect a significant difference between the effects of Treatment 1 and Treatment 2 on milk choice. Under mean comparison, the proportion is not significantly different between the two treatments (p-value = 0.88). The test of equality between the coefficients for Treatment 1 and Treatment 2 yielded insignificant result (p-value = 0.91). When added to information provision, hypocrisy inducement does not appear to have an additional effect on children's choice of healthier milk.

Table 25. *Results of classroom level analysis*

Summary Table

Average proportions of children selecting healthier milk	Delay (N = 81)	Without delay (N = 55)	Total sample (N = 136)
Control (N = 45)	0.352	0.240	0.307
Treatment 1 (Information only) (N = 46)	0.540	0.609	0.569
Treatment 2 (Information and hypocrisy) (N = 45)	0.582	0.598	0.589
Total sample (N = 136)	0.492	0.487	0.488

OLS Regression

Variable	Healthier milk choice at class level
Treatment 1	0.383*** (0.063)
Treatment 2	0.367*** (0.063)
Delay	0.250*** (0.093)
Treatment 1 ** Delay	-0.193** (0.081)
Treatment 2 ** Delay	-0.136* (0.082)
Observations	136

Notes: The models also included school fixed effects and grade fixed effects (not reported).
Clustered Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Using the same specification (1), we also observed a decline in healthier choice in both treatment groups after the delay in between the treatment and milk choice. Interestingly, we observed a main effect of the delay on the healthier milk choice. Although we assumed that the questionnaire presented to children during the delay would not influence children's choice by itself, it might have had an effect. As an evaluation for a study on fruit and vegetable consumption, the questionnaire involved questions about healthy eating habits. Although it did not mention eating less sugar and milk consumption directly, the questionnaire may have

triggered the children's thinking about healthier diet in general. Despite this positive effect, the delay still lowered the effect of the information treatments overall. β_4 and β_5 (the coefficients for the interactions between Treatment 1 and delay, and between Treatment 2 and delay, respectively) are both statistically smaller than 0. Consequently, we reject $H_0 4$ and conclude that the delay between the treatment and target behavior led to a decline in healthier food choice.

We did not detect a difference between the effects of the two treatments when accounting for a possible delay between the treatment and milk choice. β_3 appeared to be smaller than β_4: the delay in Treatment 2 only reduced the proportion of children selecting healthier milk by 13.6% compared to a reduction of 19.3% in Treatment 1. Nevertheless, this difference is not statistically significant (p-value = 0.45). The test of equality $\beta_1 + \beta_4 = \beta_2 + \beta_5$ (Hypothesis 3) also yielded insignificant result (p-value = 0.22). When there is a delay between the intervention and the target behavior, children were equally likely to select sweetened milk in Treatment 2 compared to Treatment 1.

Individual level analysis

At the child level of data, we get similar results with those from the classroom level analysis. We first ran a short logistic model with clustered standard errors to account for the treatment administration at the classroom level, including only treatment variables as the explanatory variables (column 1 Table 26). The coefficients we obtained confirmed the differences between Treatment 1 vs Control and Treatment 2 vs Control that we had detected from the summary Table 25. The children in Treatment 1 and Treatment 2 were 26.6% and 29.4% more likely to select healthier milk options than the children in Control.

Columns 2 – 4 of Table 26 displays the average marginal effects of the corresponding independent variables when we analyzed the data using the full model under specification (2)[30].

[30] We had fewer observations for the specification that includes demographic controls. Data for demographic controls were taken from the parent's questionnaire of the overarching school intervention project. This questionnaire was conducted by telephone and expectedly had a higher attrition rate.

***Table 26**. Average marginal effects on healthier milk choice using logistic regressions*

	(1)	(2)	(3)	(4)
Independent variables	Treatments	(1) + delay and interaction with delay	(2) + demographic controls	(3) + baseline milk choice controls
Treatment 1	0.266***	0.374***	0.426***	0.392***
	(0.040)	(0.060)	(0.066)	(0.0619)
Treatment 2	0.294***	0.366***	0.350***	0.327***
	(0.034)	(0.054)	(0.056)	(0.0572)
Delay	-	0.276**	0.310**	0.213*
		(0.124)	(0.125)	(0.118)
Treatment 1 ** delay	-	-0.193**	-0.240***	-0.182**
		(0.079)	(0.088)	(0.0795)
Treatment 2 ** delay	-	-0.136*	-0.113	-0.0818
		(0.071)	(0.078)	(0.0754)
Demographic controls	No	No	Yes	Yes
Baseline milk choice controls	No	No	No	Yes
Observations	1,274	1,274	999	999

Notes: The models also included school fixed effects and grade fixed effects (not reported).

Clustered Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

These marginal effects are almost identical to the coefficient estimates from the OLS model. Both treatments increased the likelihood of children selecting healthier milk by 37.4 percentage points (p-value < 0.0001), and this effect declined with a delay. With or without the delay, the effects did not differ between two treatment groups. The influence of the delay on the treatment effect appears to be smaller for Treatment 2 (-0.13) than for Treatment 1 (-0.19), but this difference is not statistically significant (p-value = 0.45). We obtain qualitatively similar results when we included demographic[31] and "baseline" milk consumption variables to

[31] The demographic variables (household size and household income) come from a parent questionnaire. This questionnaire was done via phone calls, which had a higher attrition rate and therefore a lower sample size.

specification (2) for sensitivity analysis. The results are also robust to a different construct of the outcome measure and the corresponding model specifications (Appendix 4).

Heterogeneous effects

Following the pre-analysis-plan, we ran additional logistic regressions to investigate the moderating effects of two factors: affinity for sweetened products; and initial knowledge about the health issues associated with excessive sugar consumption. We added the interaction terms between these variables with the treatment dummies to the child level analysis.

Table 27 displays the average marginal effects obtained from the two logistic regressions. As expected, affinity for sweetened products negatively correlated with the choice of healthier milk. Nevertheless, unlike our hypothesis, children who preferred sweetened milk did not show less sensitivity to the treatments. Raising the sugar affinity index by 1 point (the maximal score is 3) increased the likelihood of children selecting healthier milk by 0.05 – 0.06, but this estimate was not statistically significant.

In terms of knowledge score, although initial knowledge before the treatments had a positive influence on the milk choice, this influence was not statistically significant. Notably, the majority of the children (83.52%) could tell only one health issue related to excessive sugar consumption, which supported our assumption that the children had inadequate awareness of concerned health consequences. With such overall low knowledge score at baseline, it was not surprising to find that the few children with better knowledge did not show higher responsiveness to the treatment.

***Table 27**. Heterogeneous effects*

VARIABLES	(1) Logit Interactions with affinity for sweetened milk	(2) Logit Interactions with knowledge score Pre-treatment
Treatment 1	0.267**	0.391***
	(0.120)	(0.072)
Treatment 2	0.284**	0.392***
	(0.141)	(0.070)
Treatment 1 ** delay	-0.163**	-0.190**
	(0.077)	(0.079)
Treatment 2 ** delay	-0.122*	-0.134*
	(0.071)	(0.071)
Treatment 1 ** sugar affinity	0.051	_
	(0.061)	
Treatment 2 ** sugar affinity	0.043	_
	(0.074)	
Sugar affinity	-0.290***	_
	(0.038)	
Treatment 1 ** knowledge	_	-0.021
		(0.052)
Treatment 2 ** knowledge	_	-0.030
		(0.052)
Knowledge	_	0.033
		(0.040)
Observations	1,274	1,274
R-squared	0.156	0.073

Notes: The models also included school fixed effects and grade fixed effects (not reported).

Cluster robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In our pre-analysis plan, we also planned to analyze the moderating effects of the children's health status and level of information retention. Unfortunately, we could not collect adequate data for these variables. The majority of children could not reliably recall their own weight and height, and the schools could not provide the data on health indicators. We also decided to skip measuring information retention after the treatments, as the children were asking for help from each other instead of answering the questions themselves. The knowledge data collected would not reflect the actual individual knowledge level. More worryingly, the task took the children's attention away from the milk choice at hand, and they even had the opportunity to peek at others' choices of milk choice as they lingered after the milk choice to answer the information retention question.

We also subjected our tests of significance to the Benjamini-Hochberg correction, which controls for false discovery rate (FDR). The results discussed above still held after this correction for multiple hypothesis testing (Appendix 5).

5.5. Discussion and Conclusion

This field experiment assesses the effects of information and cognitive dissonance in nudging children towards healthier food choices. We initially hypothesize that arousing cognitive dissonance through hypocrisy inducement would improve children's food choice. We also examine whether the effects are sustained in the (slightly) longer run by adding a delay between the treatment and behavioral choice. Our work fits into a growing evidence base of "nudge for good" interventions whose designs are believed to encourage behaviors that will improve the welfare of those being nudged (Thaler & Sunstein, 2008), in particular for children's healthier food choice (List & Samek, 2015; Loewenstein et al., 2016; Belot et al., 2016).

We find that the short educational messages had a strong effect on children's milk choice during our experiment. The animation-based message increased the probability of a child selecting healthier milk options by over 30 percentage points (under no delay condition) and over 15 percentage points (under delay condition) from the pre-treatment status of about 30 percent. This result corroborates the findings of reviewed field experiments on children that also found positive impacts of educational prompts on food choices (Lai et al., 2017; Samek, 2019). Those studies used research assistants or teachers as the messengers of health information. An advantage of this trial is that we used very few resources in the approach, with the main expense being the small amount of money spent on making the video (around 300 euros). The one-minute animation almost doubled the proportion of children selecting healthier milk. This child-friendly approach has great potential in facilitating the communication of health messages to youth in Viet Nam, considering the feasibility to adapt the animation to different local contexts. Although it could be argued that the positive results were due to social desirability bias and experimenter demand effect, we believe our experimental setup helped us to circumvent this situation. The milk choice was not presented to the children as part of the experiment. They were selecting milk as a thank-you present for their participation in the overarching study. We adopted several practices discussed by Zizzo (2009) to minimize experimenter demand effects. First, we limited pressure from peers, by

offering the milk products with almost identical appearances so that the children did not have to pretend selecting a certain milk to look "appropriate" to others. The choice made by a child was also made out of sight of the other children and enumerators who were having the interviews. Second, the enumerators were not authority figures and almost strangers to the students. Third, we obfuscated the experimental objective by conducting the study as part of a larger activity.

Contrary to our predictions and pre-registered hypothesis, hypocrisy inducement did not have an additional significant effect on children's healthy food choice compared with information provision. Our result was unable to demonstrate the effect of hypocrisy inducement that Gosnell (2018) found in his study on promoting environment friendly behavior. Interestingly, while his treatment backfired among the sub-group of highly educated individuals, we found no impact among our primary school children. This helped us rule out one possible explanation that higher cognitive skill determines a higher level of experienced dissonance (Gosnell, 2018). If this explanation applied, young children would have been less tolerant of cognitive dissonance and therefore more likely to act upon dissolving the discrepancy. A more likely explanation is that by the time they finished watching the video, the children already experienced the cognitive dissonance by reflecting on their own unhealthy behavior. The information alone was sufficient to push the children towards corrective action. Therefore, when subsequently faced with the hypocrisy inducement, the children had already decided to select a healthier choice. This explanation would have been better substantiated if we had collected a measure of cognitive discomfort or discrepancy, or a measure associated with hypocritical feeling such as guilt. However, as we argued under the Methods section, such measures as manipulation checks may affect experimental conclusions (Hauser et al., 2018). It is even more challenging for the child subject group who have difficulty sustaining their concentration and articulating their feelings and thoughts. Future research has room to overcome these pitfalls and substantiate the explanations by exploring innovative measurements.

Our result does not necessarily challenge previous studies that found hypocrisy inducement effective in promoting behavioral change among children. Prior studies, such as those by Morrongiello & Mark (2008) and Ager et al. (2008) noted the effective use of hypocrisy inducement in correcting behaviors, but their interventions also educated the children through

their activities. What we contribute to the literature is an indication of how much hypocrisy inducement can add to education. In this context, the two-step hypocrisy inducement was not a successful paradigm to nudge children further towards healthier choice. The finding suggests a positive pedagogical message: "guilt-tripping" may not be a desirable approach to children's education, not for its possible emotional harm, but simply due to its ineffective nature. To change children's behavior, giving them the information needed in an approachable way may be enough.

We tried to capture the persistence or erosion of treatment effect by introducing a small delay between the treatment and the choice behavior. A fifteen-minute delay reduced the effect by half (for treatment 1) and a third (for treatment 2) relative to the no-delay condition. This effect erosion calls for extra caution when judging an experimental study's external validity. Once the treatment ended, the child could have forgotten the information and no longer feel motivated to eat healthier. Alternatively, he or she could have found other means to resolve the cognitive dissonance such as actively forgetting and getting distracted (McGrath, 2017). In order to convert a one-time healthier choice (selecting less sugar milk) into a sustained healthy behavior (eating healthier foods), behavioral change communication requires consistent reminders to induce habit formation. Nevertheless, treatments that make considerations newly applicable or provide new information persist longer (Coppock, 2017). The focus of our treatment was to provide simple practical tips to eat healthier, as well as to introduce healthier options to children. Given such features, we can be optimistic about the potential effect in the long run of our treatments. Our approach is still an attractive option to combine with other habit-forming interventions thanks to its scalability. Future experiments in longer run studies could test if this optimism is well-placed. Simply coming back to the school after one week, for example, would help to gauge how much of the effect of the information treatment still exists, and how the cognitive dissonance treatment may affect the persistence of the information shock. Future research can also test if repetition of the health tips can support habit formation and how often the reminders should take place.

Although it was not the focus of our study, our results suggested that the sheer availability of healthier product might play a role in promoting healthier eating among children. Unlike children in developed countries, the children in our experiment had less experience with healthier products such as reduced sugar and unsweetened milk. While over 80% of the

children usually consume sweetened milk, only 70% in the control group selected sweetened milk when presented with healthier options in the experiment. This could be due to the attraction to novelty, or simply the possibility to exercise their own choice given more variety. We do not make any causal claim about either of these reasons, as we could only measure the "baseline" milk consumption using self-reported answers and use a simple before-after comparison. Nevertheless, parents and educators can benefit from this observation to try experimenting with healthier products to deliver to their children.

One of our limitations is the lack of power to detect the interaction effects. As stated in our pre-analysis plan, our study might be underpowered to test hypotheses regarding interactions between the delay and treatments. Unfortunately, this inadequate power is prevalent in studies with interactions (Muralidharan et al., 2019). With a delay, although the effect appeared to reduce less under the hypocrisy inducement condition, this difference was not statistically significant. We therefore could not make statistical inference about the relative effectiveness of hypocrisy inducement in a longer run. Future research can strive to adjust this limitation, for example by increasing the sample size or focusing on the long run effects.

Finally, the concurrent implementation of this research with the endline data collection of a larger study had some important implications. On one hand, we could use the bigger context as a veil for our intention to measure behavioral outcome and reduce potential social desirability and experimenter demand bias. We also took advantage of the data collection process to add a condition (the delay) to our experiment. On the other hand, this very delay, which was just intended as a "filler" task, introduced some noise. Data showed that simply answering the questions for another study on a related topic – consumption of fruit and vegetable – during the delay nudged the children towards healthier choices. The information provided during this delay could have acted as a priming device for attention to health, and a substitute for our information treatment and reduced the main treatment effect. Although this did not change the results in our case, it is very important that researchers are transparent about these add-on studies to draw valid inferences. The implementation constraints also prevented us from conducting additional measures, for example on ex-post beliefs about sugar, or level of guilt, to offer better explanations of the mechanism hidden in our results.

Appendices

Appendix 1. Experimental set-up and procedures

The lab-in-field experiment is conducted in December 2019. The experiment is designed to be integrated with the second endline of another on-going project ("Improving Diets in Schools in Viet Nam: Testing Innovative Methods of Influencing Demand")[32], so that it appears as non-intrusive to the students and the schools as possible.

The enumerators who interview the children for the endline 2 questionnaire are also the implementers of the treatments.

Recruitment and inclusion/exclusion criteria:

All the children who are eligible for the endline 2 survey of the aforementioned project are included in this lab-in-field experiment. The children and their parents will be consented (using the attached consent forms). These consent forms (Consent form A) should be sent by the school to the parents one week before the start of the endline 2 survey.

If any child has an allergy to dairy products, which will be informed by his/her parent as they return the consent form, he/she will be excluded from the lab-in-field experiment (even though he/she can still join the endline 2 survey).

Organizing the interviews by class:

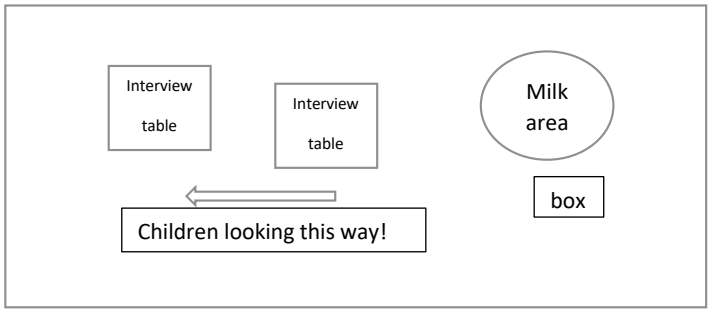
As the treatment is randomized at classroom level, it is important that children from different classes do not share about the experiment with each other.

All the targeted children in a class should be covered before the enumerators proceed with the next class, so that children from different classes cannot speculate what their mates in other classes are doing differently (although the procedure will look similar between treatment groups). Ideally, the teams of enumerators will interview children from different classes in different rooms, and finish interviewing one full grade (all the classes in a grade) in a school at the same time, so that children from different classes in a grade do not have the chance to share information with each other.

[32] Detailed in the previous chapter, this project is an RCT that seeks to increase children's consumption of fruit and vegetables. It includes lessons about benefits of eating fruit and vegetables and provides fruit for children. All of these took part in the previous school year.

If this cannot be done, the interviews should end at least 20 minutes before/after the school break(s), so that children from different classes can return to their classrooms immediately to continue the daily lessons, without having the chance to talk with each other by interacting during the break.

Set-up before the interview:



We want the children to make individual choices when selecting their milk (in the final step of the pre-test) so if the milk delivering area is in the same room with the interviews, the children should turn their back against this area, so that they cannot observe other children's choices.

The following materials should be ready:

- Tablet with the installed forms, video and headset. The data should be transmitted to MDRI's server immediately so entered data can be checked and cleaned as soon as possible.
- Forms for children to fill in (according to their control/treatment status)
- Thank you notes for children after completing the experiments
- Enough milk for children to make their own choices. Three types of milk should be put in three almost identical boxes, with the only difference being the labels of the box to indicate which milk is inside. These labels should be positioned so that they are visible to the children coming close to select the milk. For "outsiders" the three boxes should look identical.
- A box for children to drop their anonymous sheets
- Note-taking materials

Obtaining consent from the children and going through the questionnaire:

At the end of the endline 2 questionnaire, the enumerator will tell the student about this study, using the information sheet provided (Consent form B). Once the child agrees to participate, the enumerator can proceed with a couple of questions related to the experiment (one on their milk usage/preference and one on their knowledge about excessive sugar intake) (Instrument 1).

In the first 6 schools, the order of the study components is as follows: Instrument 1 -> Endline2 questionnaire -> Treatment -> Milk choice.

In the second 6 schools, the order of the study components is as follows: Instrument 1 -> Treatment -> Endline2 questionnaire -> Milk choice.

These orders will also be programmed into the data collection application installed in tablets, so that the enumerators only have to remember this order if the tablet fails and they have to resort to paper research instruments.

Playing the video to children

The educational videos will be programmed on the tablet, so that the students in a class get the corresponding video played to them, depending on their control/treatment status. If it is noisy and/or the child is not alone/with other students in the same room, they will receive earphones.

Control group: a placebo video (educational, non-nutrition related contents, e.g. wearing helmet while driving a motorcycles https://www.youtube.com/watch?v=vohkCg_DDRM)

2 Treatment groups: a video about eating excessive sugar and how to limit sugar in their diet. This video is installed in the tablet program (Figure 12).

***Figure 12**. Screenshot of the video*

Inducing cognitive dissonance (only for Treatment 2)

Public statement: After watching the video, the children in Treatment 2 are given a script to share the message of eating less added sugar to other children. The children are also told that this message will be recorded to share with children in other schools.

Asking questions linking to the past behavior of children: After reciting the health promotion script, the children in second treatment group will be asked a number of questions to remind them of their usual eating behaviors. These questions are included in Instrument 3. These questions will not be programmed into the tablet but printed out for the children to privately answer them (without the enumerator knowing the answers) (Instrument 3). Once the questions have been answered, the children will put the anonymous answer sheets into a box which will be collected by the enumerators later. All the recordings will be saved and played to the children in the next school projects that MDRI (the survey partners) are involved in.

Thanking the students by offering them a choice of milk

This is the last step of the experiment. The enumerator thanks the children for participating in the survey. As a thank you token, the enumerator tells the child that he/she can go pick up one milk carton from the stacks ready for them. To reduce desirability bias, the children will go to an area where they can choose the milk out of sight of the interviewer. The milk cartons will be arranged in three stacks (one plain milk, one sweetened milk, and one less sugar milk).

Another research assistant (who has not interviewed the child) will observe the children's choice and notes down the choice of the children. Clear coding instructions will be in place to ensure the milk choices match the corresponding students.

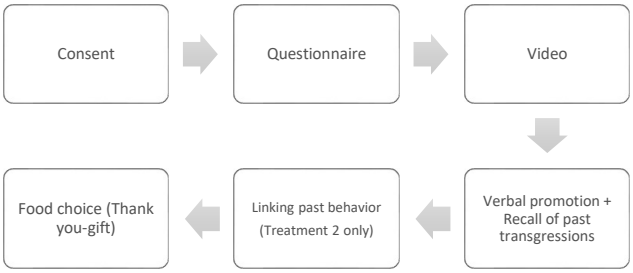


Figure 13. *Workflow of the experiment*

Appendix 2. List of baseline covariates (Control variables)

Control variables	Type	Description
Baseline milk choice		
Tried unsweetened milk before	Dummy	0 = No; 1 = Yes
Tried sweetened milk before	Dummy	0 = No; 1 = Yes
Tried reduced sugar milk before	Dummy	0 = No; 1 = Yes
Most frequently consumed milk	Categorical	1. Sweetened 2. Reduced sugar 3. Flavored milk 4. Unsweetened or reduced sugar non-dairy 5. Sweetened non-dairy
Most frequently consumed milk	Categorical	1. Sweetened 2. Reduced sugar 3. Flavored milk 4. Unsweetened or reduced sugar non-dairy 5. Sweetened non-dairy
Demographic		
Male	Dummy	0 = No; 1 = Yes
Household size	Continuous	1 – 10
Household income quartile	Categorical	5. 1st income quartile 6. 2nd income quartile 7. 3rd income quartile 8. 4th income quartile

Composite Index for heterogeneous effect estimation		
Affinity for sweetened product score	Continuous	0 – 3 Total score of the following: If the most frequently consumed milk is sweetened: 1; 0 otherwise If the child has never consumed reduced sugar or unsweetened milk: 1; 0 otherwise If the child's favorite milk is sweetened: 1; 0 otherwise
Knowledge at baseline score	Continuous	0 – 6 Number of each correctly named health issue related to sugar consumption

Appendix 3. Balance check: Test of joint orthogonality using multinomial logit regressions

	Variables	Treatment 1 relative to Control	Treatment 2 relative to Control	Delay vs No delay
Baseline milk choice dummy	Tried unsweetened milk before	-0.008	0.110	-0.316**
		(0.177)	(0.184)	(0.152)
	Tried sweetened milk before	-0.546	-0.397	-1.267
		(1.124)	(1.312)	(1.073)
	Tried reduced sugar milk before	0.476***	0.193	-0.084
		(0.182)	(0.173)	(0.148)
	Most frequently consumed milk: Sweetened	0.209	0.200	0.409
		(0.389)	(0.387)	(0.333)
	Most frequently consumed milk: Reduced sugar	0.009	0.307	0.361
		(0.538)	(0.485)	(0.419)
	Most frequently consumed milk: Flavored milk	0.133	-0.018	0.517
		(0.424)	(0.405)	(0.364)
	Most frequently consumed milk: Unsweetened or reduced sugar non-dairy	0.088	-0.418	0.811
		(0.861)	(0.777)	(0.790)
	Most frequently consumed milk: Sweetened non-dairy	0.683	0.523	0.146
		(0.443)	(0.435)	(0.377)
	Favorite milk: Sweetened	-0.541	-0.117	0.279
		(0.406)	(0.472)	(0.363)
	Favorite milk: Reduced sugar	-0.810*	0.057	0.813*
		(0.469)	(0.540)	(0.420)
	Favorite milk: Flavored milk	-0.326	0.161	-0.220
		(0.406)	(0.451)	(0.362)
	Favorite milk: Unsweetened or reduced sugar non-dairy	-1.525*	-0.225	0.641
		(0.881)	(0.631)	(0.573)
	Favorite milk: Sweetened non-dairy	-0.920**	-0.294	0.314
		(0.429)	(0.491)	(0.386)
Demographic dummy	Male	0.084	0.182	-0.068
		(0.152)	(0.156)	(0.128)
Demographic continuous	Household size	-0.078	-0.115	-0.130*
		(0.091)	(0.080)	(0.072)
Demographic dummy	Household income quartile = 2	0.173	0.186	-0.199
		(0.251)	(0.233)	(0.193)
	Household income quartile = 3	-0.159	-0.339	-0.061
		(0.228)	(0.223)	(0.189)
	Household income quartile = 4	-0.093	-0.189	-0.207
		(0.256)	(0.247)	(0.204)
	Constant	0.997	0.639	1.928
		(1.320)	(1.485)	(1.229)
	Observations	999		999
	Chi-square test	45.89		39.80
	P-val	0.125		0.002

Cluster robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Appendix 4. Additional results

Table 4.a. Logit regression using the healthiest choice (unsweetened milk) as the binary outcome variable

	Average marginal effect on healthiest milk choice
Treatment 1	0.369***
	(0.054)
Treatment 2	0.333***
	(0.055)
Delay	0.149
	(0.105)
Treatment 1 ** Delay	-0.138*
	(0.072)
Treatment 2 ** Delay	-0.044
	(0.071)
Observations	1,274

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.b. Ordered logit regression using three milk choices as outcome variables

Average marginal effect	Treatment 1	Treatment 2	Delay	Treatment 1 ** Delay	Treatment 2 ** Delay
Pr(milk choice = unsweetened milk)	0.119***	0.122***	0.107***	-0.0642***	-0.0561**
	(0.021)	(0.021)	(0.031)	(0.025)	(0.024)
Pr(milk choice = reduced sugar milk)	0.214***	0.220***	0.192***	-0.116***	-0.101**
	(0.032)	(0.032)	(0.052)	(0.043)	(0.043)
Pr(milk choice = sweetened milk)	-0.333***	-0.342***	-0.299***	0.180***	0.157**
	(0.050)	(0.050)	(0.081)	(0.067)	(0.067)
Observations	1,274	1,274	1,274	1,274	1,274

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix 5. Corrections for multiple hypothesis testing

Hypothesis	Unadjusted p-values	Adjusted p-values (Benjamin & Hochberg)
H1: both treatments have a positive effect on children's food choice		
$\beta_1 > 0$	0.000***	0.000***
$\beta_2 > 0$	0.000***	0.000***
H2: hypocrisy inducement has an added effect on information		
$\beta_1 < \beta_2$	0.555	0.624
H3: the effects of both treatment decline with the delay		
$\beta_4 < 0$	0.007***	0.023**
$\beta_5 < 0$	0.028**	0.070*
H4: treatment 1 and 2 have a similar effect in the long run.		
$\beta_1 + \beta_4 = \beta_2 + \beta_5$	0.284	0.568
Heterogeneous effect of treatment 1: affinity for sweetened milk	0.407	0.624
Heterogeneous effect of treatment 2: affinity for sweetened milk	0.562	0.624
Heterogeneous effect of treatment 1: baseline knowledge	0.679	0.679
Heterogeneous effect of treatment 2: baseline knowledge	0.561	0.624

*** p<0.01, ** p<0.05, * p<0.1

CHAPTER 6

General Discussion

The pathways for most food systems changes are designed at local and national levels to facilitate contribution to sustainable development (FAO, 2017a; Caron et al., 2018). Taking Vietnam as the playground for exploration, this thesis has attempted to answer both descriptive and causal questions to identify leverage points to improve consumption and nutrition outcomes in the local food system.

6.1. Revisiting the research questions

The first study in this thesis (Chapter 2) describes the inclusive process of creating a national food system profile and consulting multidisciplinary stakeholders to determine research priorities for Vietnam's food system. This is one of the first studies that summarize and present the follow-up results from food systems research priority setting (FSPR), after papers that present the research priorities without reporting on the initial implementation of such priorities (Gebru et al., 2018; De Brauw, Waid, et al., 2019; Raneri et al., 2019).

As demonstrated by the case study of Viet Nam, FSPR can successfully adopt several good practices from health and nutrition priority setting, such as the assessment of existing evidence with extensive data, a clear method for deciding on priorities, the inclusion of a broad range of stakeholders, and adopting transparency principles. Besides, FSPR has to take into characteristics of food system analysis that make the task of prioritization more challenging. First, food systems encompass multiple sectors and disciplines, requiring the involvement of transdisciplinary stakeholders. As seen in later chapters, in studying food system elements and interventions, we used methods from different disciplines such as ecological assessment and public health (Chapter 3), nutrition (Chapter 4) and psychology (Chapter 5). Second, it covers multiple outcomes that require respective indicators to incorporate into setting criteria and ranking priorities. Third, it requires significant amounts of data not only from different domains but also from different time points due to the adaptive and dynamic nature of the food systems. We also highlight the need for a concrete follow up plan to track and monitor the impacts of such a priority setting exercise. Findings that stem from research priorities, such as those from

Chapter 4 and 5 on school food environment, have to be mapped to a monitoring, evaluation, and learning system. We endorse the recommendation that to avoid research waste, responsibility lies with researchers and research funders to be transparent about the potential users of research and strengthen information about research that is in progress (Chalmers et al., 2014).

Chapter 3 zoomed in one key component of a food system – the food environment – and compared its characteristics across a local urban – peri-urban – rural transect. This chapter focusses on the community-scale food environment, as distinct from the school-food environment (Turner et al, 2020), which we tackle in Chapter 4 and Chapter 5. Similar to a limited number of food environment studies that looked at more than one location (Liao et al., 2016; Wang et al., 2017; Spires et al., 2020), we found significant differences in food availability across the three sites in North Viet Nam (Chapter 3). The urban area exhibits the highest food outlet density and variety, while the rural food environment is characterized by a limited variety. Urban and peri-urban households enjoy a closer proximity to food service shops than rural households who depend the most on at-home consumption and home-grown products.

We argued that the widespread availability and low prices of unhealthy foods even in the most accessibility-deprived communities might be responsible for the observation that peri-urban and rural areas on average had higher consumption of ultra-processed foods than in the urban area. This result is contrary to the common concern that urban households are the major consumers of processed foods due to modernization and supermarketization (Popkin, 2006; Wagner & Brath, 2012; World Health Organization, 2016). Besides, we pointed to the lack of diversity of healthy foods in the disadvantaged neighborhoods as an important leverage to tackle child undernutrition, a claim that has been substantiated in previous studies (Debela et al., 2020; Khonje et al., 2020).

Chapter 4 and 5 provided the results of the evaluation of two pilot interventions implemented in the school-based food environment, one of the priorities identified in Chapter 2. We found that information-based interventions, either in the form of weekly lessons or educational prompts, can have significant effects in the short run on interested outcomes, such as nutritional knowledge (Chapter 4) and healthy food choice (Chapter 5), but these effects can quickly dissolve after a relatively short period, be it a summer holiday or 15 minutes of

intervening activities. The 5-week-long nutrition lesson failed to change the attitude towards consumption of healthy foods, mostly due to the lack of inherent enjoyment in consuming the available foods at school. The poor quality of the meals provided to children during lunch prevented the children from eating more fruit and vegetables, even though they were better aware of the issues of not eating enough FAV. In follow-up qualitative interviews with the children, the children expressed a strong dislike to the vegetables prepared at school. Given the prominent role of taste liking in children and young adults' food selection (S. P. Nguyen et al., 2015; Boesveldt et al., 2018), addressing the school meals' taste quality is crucial to the effectiveness of nutrition education. This demonstrates the interaction between the external food environment dimension (availability of vegetables in school) and the personal environment dimension (students' desirability regarding vegetables) that constraints healthy consumption. These concepts of personal and external food environment domain are explained in more detail in the previous chapter (Chapter 3). Similar to the results of a few studies with similar set-ups, but exclusively in high income countries (Bartlett et al., 2013; Micha et al., 2018; Verdonschot et al., 2020), we found that providing access to healthy food in the school environment could be a good way to raise children's healthy food consumption, without a substitution effect between fruit provision at school and home fruit consumption. The findings add to the discussion in Chapter 3 about increasing availability of healthy foods not only the community, but also in the school environment.

6.2. Limitations

The limitations of each individual study have been discussed in the corresponding chapters. Hereby I discuss the overall limitations of the thesis when looking at all the chapters together.

Although the thesis strove to adopt a food system approach, except the first chapter, the subsequent chapters mostly looked at individual components of the food system, without explicit linkages to other components, as well as the potential synergies, feedback loops or trade-offs involved among them (Ericksen, 2008; Béné et al., 2019). For example, Chapter 4 is mostly limited to school environment and the demand side of fruit and vegetable consumption. The intervention attempted to generate a feedback loop by getting parents involved in planning children's school meals, but this was unsuccessful due to lukewarm participation of parents. By encouraging children to eat more fruits and vegetables, we could also help address the issue of

food waste, a globally pressing issue with low visibility (Blakeney, 2019; Chen et al., 2020; Derqui et al., 2020), as the sampled children were not consuming up to half of what was offered during school lunch. As information on dynamic consequences of interventions is not available, this thesis has yet to cover secondary outcomes such as environmental or socio-economic outcomes which are key elements of sustainable food systems (Béné et al., 2019). In chapter 3, we promoted retail improvements that help increase dietary diversity among rural households. Nevertheless, a more diverse/varied diet has been associated with higher greenhouse gas emission, especially due to meat consumption. From an environmental perspective, meat consumption is a concern, but from a nutritional perspective, it can contribute significantly to the intake of essential nutrients among more disadvantaged communities (Trinh et al., 2021).

In terms of geographic coverage, due to the limited resources, the study on the school environment could only be carried out in one study site, so the inferences drawn from this study cannot be easily translated to the other locations. The diversity of the food system within a transect, which is demonstrated in the second study, means that it is not a simple task to extrapolate the results to different settings. Experimenting with the school interventions in all the three sites would have enabled a more rounded view of the food system issues across the selected transect.

The sample of this thesis has several characteristics that limits its findings' external validity. Three sites in the North were selected as benchmark to study the characteristics of food system along a rural-peri-urban-urban transect (de Haan et al., 2017). Although this selection allows for a thorough analysis of the food environment in an LMIC in nutrition transition like Viet Nam, the selected sites are not geographically and demographically representative of either the region or the country. In chapter 3 (food environment study), as the collected data also served the purpose of nutritional assessment, half of the sampled households for the household surveys were limited to those with children under 5. Therefore, the respondents in the sample are in general younger than in a more representative dataset.

The implementation of data collection methods could be improved. For the first study on priority setting, a better mechanism of communication between co-authors and stakeholders would have sped up the process and enabled more points of evaluation. For the working paper, we took a long time to collect all the feedback from the stakeholders until the priority-setting

workshop. For the second study on food environment, a great deal of GPS data points in peri-urban and urban areas were lost due to logistics constraints and a lack of clear definition of the purpose of the GPS data collection exercise. In the third study (school RCT), we could have implemented an alternative method to collect data from parents to reduce the non-response rate, e.g. by interviewing them during parents' meetings, instead of making phone calls. We did not succeed in collecting paper-based food diaries from parents. This could be changed in the future as parents are becoming more tech-savvy. Data collection can be done with an interactive app in the likes of calorie counter apps such as Fooducate and Lifesum.

Although food system research requires a multidisciplinary and even better a mixed method approach (Turner et al., 2020), this thesis has been mostly either quantitative (Chapter 4 and Chapter 5) or qualitative (Chapter 2), except for the chapter on food environment. For the school-based studies, although a qualitative scoping study was initiated to start designing the interventions, the evaluation was mostly quantitative in nature. Greater use of mixed methods could help to offset some of limitations of RCTs and to place their findings on much firmer ground by combining with other methods to understand not only "what works" but also "why things work" (Deaton & Cartwright, 2018; Kabeer, 2019). For example, I would have liked to spend more time in the field with the children to understand the role of the supply side in qualifying our results, and understanding better the mechanisms of why the intervention failed to influence the attitude of children towards FAV consumption. All the empirical papers (Chapter 3, 4 and 5) could also benefit from a longitudinal dimension: While seasonality and temporal constraints are very valuable for food environment assessment, we did not capture them empirically. Although the last two chapters introduced longer term evaluations, we did not compare different durations of the interventions themselves, while successful interventions may have to last at least a year to be effective, and evidence of the long-term sustainability of these impacts is still limited (Black et al., 2017; Verjans-Janssen et al., 2018).

6.3. Synthesis

When all the chapters are considered together, at least three extra insights emerge: the value of food system approach in furthering research for improved consumption and health outcomes; the need for transparency in field research; and attention to data gaps for food systems research in LMICs.

Food system approach for healthier outcomes

The concept of food system and its approach reflects the attention to multiple development concerned caused by a failing food systems (Pinstrup-Andersen, 2007; HLPE, 2017; Béné et al., 2019). Covering the different elements of the food system, pieces of findings from the separate chapters helped to bring out the holistic picture of a local food system. What Chapter 4 showed us is that increasing demands for healthy foods in school will face the hurdle of supply constraints, which limits significantly the ability of children to eat healthy food. In the peri-urban area, supply for fruits and vegetables came mostly from local sources, but the food providers for schools were not confident enough about the quality of the FAV provided to bring in more interesting choices for children. From the snapshot of the food environment in the peri-urban area in Dong Anh (chapter 3), we understand the limited availability of food outlets at the community level, which puts the role of the school environment extra important in facilitating better diets for the children. Future studies can combine and explore the improvements in food environment at both school and community scale, with consideration for trade-offs and feedback loops.

This thesis also demonstrates the multidisciplinary methods needed to tackle the dietary and health issues in question. The thesis combined evaluation techniques in development economics with approaches from other fields. Besides causal inference techniques (RCT), Chapter 4 borrowed heavily from the methods used by nutritionists to assess dietary outcomes. Chapter 2 used an approach commonly used in health priority setting research and applied it in food systems research. Economic techniques such as cost-benefit analysis and optimization methods can be utilized in ranking activities. Chapter 3 uses methods inherited from public health, for example the use of GIS methods to analyze disparities in access to health-care (McLafferty, 2003). Measuring the diversity of retailers can benefit from the methods used by ecologists in evaluating the diversity of species or genomes in an environment (Gotelli & Colwell, 2001). Contributions from different disciplines are enriching: Nutrition research can benefit from economic explanations of individual behavior and societal outcomes, while economics research can benefit from nutrition science to understand the causes and consequences of dietary intake (Finaret & Masters, 2019).

As the title of the thesis suggests, the findings of this thesis provide inputs for the design of further innovations. De Brauw et al. (2019) developed a typology of food system innovations with examples (Figure 14). The recommended school information interventions (Chapter 4 & Chapter 5) address the "consumer behavior" target element, at the intersection between technology and institutional innovations. From an economic perspective, such interventions help to shape curvature of the consumers' utility function, catalyzing increased demand for healthier food (Allen & de Brauw, 2018). Additionally, if local governments adopt the school fruit provision program into the school food environment, they can purchase fruit from local farmers under a public food acquisition program, such as Brazil's effort to link its school feeding program with incentivizing local farmers to grow more nutritious foods under its Zero Hunger initiative (Sidaner et al., 2013). Chapter 3 provides insights for further considerations of introducing innovations at policy/regulation and institutions' levels. It promotes retail outlet transformation, especially in rural areas, and taxes on unhealthy foods such as sugar-sweetened beverages (SSB). To bring the recommendations by this thesis forward, further research is needed to address the costs and benefits of up-taking a food system innovation, considering the multiple economic and political constraints faced by the type of proposed changes. For example, a successful passage of SSB tax in Mexico, despite opposition from a strong national SSB industry, required high level cooperation, public relations campaigns, and framing tax as revenues to enable buy-in from policy-makers (James et al., 2020).

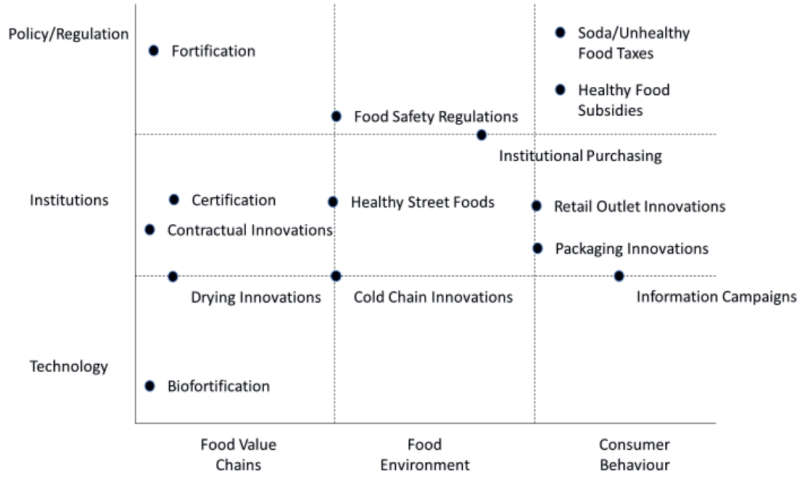


Figure 14. *Typology of Food System Innovations (de Brauw et al., 2019: Fig. 2)*

Data gaps in food systems research in LMICs

Across the chapters, we experienced varied levels of data gaps in characterizing and assessing various elements of the food system. A recent review on food systems data in Viet Nam showed that most of the datasets collected information related to food access, consumption, and nutrition, less than a fifth of the dataset dealt with food processing and distribution (Burra et al., 2019). Although we dealt with consumption and nutrition data, the available datasets are not helpful. For example, in Chapter 4, to measure food consumption of children, we spent a significant amount of time converting food recipes and proportions into grams, given the lack of a food recipe database for Viet Nam. A Vietnamese food composition table published by the National Institute of Nutrition is available, but it does not include a wide range of locally eaten mixed dishes (Viet Nam National Institute of Nutrition, 2017). Where data is available, it is not for public access (e.g. from NIN). Similarly, there was a complete lack of data on the nutritional values of processed foods, which prevented chapter 3 from making comparisons that are more meaningful between the sites in terms of processed food consumption. Similar studies on the same subjects (for example consumption of schoolchildren) were also not publicly available, making tasks such as assessing the representativeness of our dataset difficult.

In characterizing food environment, the lack of a database of streets or GPS data in the most disadvantaged areas posed a significant challenge. The lack of exact household GPS data points, especially in rural and peri-urban areas, also prevented our analysis from conducting quantitative analysis of the correlation between food environment factors and outcomes. This drawback therefore limits comparison with similar studies, such as by Dake et al. (2016) in Ghana and Patel et al. (2018) in India, which utilized geocoded data to discover the relationship between outlet characteristics and body mass index. In high-income countries, locations of the households and food outlets could be geocoded using available extensive administrative data without field data collection (Chaix et al., 2012; Aggarwal et al., 2014). We also missed out the opportunity on characterize other dimensions of the food environment, such as transportation and processing, due to a complete lack of data.

There has been a call to improve the quality and scope of data related to food systems (Turner et al., 2018). In response to the call, this thesis has attempted to collect primary data useful for several purposes. Data used in Chapter 4 could be used to investigate food waste in school food

environment, filling the gap of research on food waste in LMICs. When taken up by a nutritionist, consumption data from food diaries can be further analyzed to quantify the diet of school children according to food groups and macronutrients. In Viet Nam, to my knowledge, the Young Lives survey data was the only source that covered dietary consumption of school age children, but the indicator derived from the data has been limited to dietary diversity score calculated from the presence of food groups in the diet (Aurino et al., 2017; Humphries et al., 2017).

Research transparency in practice

Transparency is one of the core scientific principles to improve efficiency, facilitate self-correction, and enhance the credibility of the published literature (Miguel et al., 2014; Hardwicke et al., 2020). However, although researchers appear to endorse the values of transparency, they are routinely neglected in practice (Hardwicke et al., 2020).

In this thesis, the conversation around transparency started from Chapter 2, where we discussed how the priority setting process for food systems research benefits from the transparent and inclusive involvement of stakeholders. Additionally, monitoring the outputs and outcomes of the priority setting exercise could be made more transparent by a clear follow up plan. The plan details how the prioritized questions could be pursued and how to measure the impacts of such pursuits. The uptake of research priority exercises is limited so far, a result in line with what has been assessed in an adjacent area - priority setting exercises in nutrition (Hawwash et al., 2021).

In Chapter 5, we were transparent about that fact that the design and findings of the study came about by piggybacking off another study in the preceding chapter. Researchers frequently make use of data collection efforts to yield several groups of findings, for example implementing economic evaluation studies based on individual patient data during randomized controlled trials (RCT “piggyback”) (Petrou & Gray, 2011), or implementing cross-cutting designs in implementing and evaluating social interventions (Duflo et al., 2007). In our case, we implemented a lab-in-field experiment during the endline-data collection of a randomized control trial. While the concurrent implementation of an add-on research with the endline data collection of a larger study had some important advantages, it introduced some noise to the

study design, as discussed in the chapter. It is very important that researchers are transparent about these add-on studies to draw valid inferences.

Following the call for registered studies, the two experiments in Chapter 4 and Chapter 5 were both pre-registered. The advantages and disadvantages of pre-registration have been discussed thoroughly by Olken (2015). In our case, it certainly has safeguarded us against the issue of data mining and specification searching, enabling us to report on null results. As we were working with local partners who implemented the intervention, pre-registration also protected us against the social pressure to slant results. Nevertheless, pre-registration has also got us caught up on the specific hypothesis, which is more demand-driven, at hand, missing the chance to account for the surrounding mechanisms, more supply-driven, that helped explain our unsuccessful treatment. The limited team of researchers also meant that the practice of monitoring program implementation using unblinded data, while at the same time adjusting the analysis plan based on blinded data, was not possible. The process of preparing the two experimental studies displays stark differences from that of chapter 3, whose data came from a baseline dataset that could serve multiple purposes and researchers could use it for several purposes ex-post. The chapter used pre-existing data to run exploratory analysis using a pre-determined framework. We made no effort to p-hack our way to statistically significant and eye-catching results. Currently, pre-registration of secondary data analysis study is "very much imperfect business", and I hope to see new developments in this area, as discussed by Weston et al. (2019).

6.4. Societal relevance

Research is expected to meet societal challenges and to interact responsibly with society (Greenhalgh et al., 2016; Sivertsen & Meijer, 2020). A brief assessment of social relevance of this thesis follows the guide by Maassen van den Brink et al. (2010).

Regarding potential impact and use of results, this research project has yielded several research findings linked to socially desirable outcomes for the population like improved health and nutrition. The policy implications have been discussed in the respective chapters (2, 3, 4, 5). Beyond the local context of the project, what we have learned from Vietnamese data would offer opportunities to draw lessons and implications for other settings, especially countries with similar concerns of DBM and going through the nutrition transition (Chapter 1). As this thesis

fits under an overarching multi-country research program, there are possibilities to compare and contrasts the results with different similar studies. For example, the methodology used by the second chapter study can be used to analyze the priority setting exercises in Bangladesh (De Brauw, Waid, et al., 2019) and Ethiopia (Gebru et al., 2018).

In terms of interaction between researchers and societal stakeholders, the completion of this thesis has benefitted from support and cooperation of the stakeholders expected to benefit from the research results: government body that helps shapes policies (National Institute of Nutrition), local governments (in 3 study sites) and school administrators (in peri-urban Dong Anh). Besides addressing issues that the local communities are faced with, our research has also familiarized the stakeholders with our approach. As briefly described in Chapter 2, the food system concept and frameworks have been recognized by technical government agencies. Moreover, my conversation with local school administrators also revealed their interest in the project and understanding of our experimental methods. To disseminate the knowledge, all the preliminary results of the studies have been shared with the stakeholders, via blog-posts[33], workshops and personal conversations for those not fluent in English. Whether the policy implications of research findings can make an impact demands time and advocacy capacity of us, as academics, and our networks. The dataset for Chapter 3 is open access on CGIAR's server, and datasets for Chapter 4 and 5 are ready to be uploaded on online depositories. I believe these datasets will be of use for other researchers, including economists and nutritionists, who are interested in studying consumption and food systems.

[33] https://a4nh.cgiar.org/2020/11/03/new-research-in-viet-nam-shows-holistic-approach-to-school-based-interventions-required-to-promote-healthy-eating-among-children/
https://blog.ciat.cgiar.org/update-food-systems-for-healthier-diets-a4nh-contributions-to-the-nutrition-sensitive-movement-in-vietnam-continue/

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English Summary

This thesis uses a food system lens to characterize the components of a local food system (Viet Nam) and identify the potential leverages for innovation and intervention. It evaluates pilot interventions to improve consumption of healthy foods as an outcome of the food system, contributing to emerging scientific evidence base on food systems innovations.

In Chapter 1, I set the stage by explaining how food systems research can help address the global health and development concerns, presenting the research questions and discussing the key topics of the thesis: priorities in food systems research, food environment and school-based interventions for healthier diets. The specific research questions are: How can research priorities be defined for a local food system, considering practices from other domains? (Chapter 2); How do food environment characteristics vary across a local transect? How are their relationships with consumption and nutrition outcomes? (Chapter 3); What are the potential impacts of interventions to improve children's consumption in a food environment setting? (Chapter 4 and Chapter 5).

The first study in this thesis (Chapter 2) critically reviews the inclusive process of condensing a large amount of data into a national food system profile and determining research priorities for Vietnam's food system. From the case study of Viet Nam, we conclude that food system research priority setting can successfully adopt several good practices from health and nutrition priority setting, such as the assessment of existing evidence with extensive data, a clear method for deciding on priorities, inclusion of a broad range of multidisciplinary stakeholders, and adoption of transparency principles. Additionally, the exercise has to take into account the characteristics of food system analysis that make the task of prioritization more challenging, namely the multi-sector, multi-outcome and dynamic natures of food systems.

In Chapter 3, we found significant differences in food availability across the three sites in North Viet Nam (Chapter 3). The urban area exhibits the highest food outlet density and variety, while the rural food environment is where traditional independent small grocery stores make up the major share. Urban and peri-urban households enjoy a closer proximity to food service shops than rural households who depend the most on at-home consumption and home-grown products. We argued that the widespread availability and low prices of unhealthy foods even in the most accessibility-derived communities might be responsible for the observation that

peri-urban and rural areas had higher consumption of ultra-processed foods than in urban area. Additionally, we pointed to the lack of diversity of healthy foods in the disadvantaged neighborhoods as an important leverage to tackle child undernutrition.

Chapter 4 and Chapter 5 provide the results of the evaluation of two pilot interventions. We found that information-based interventions, either in the form of weekly lessons or educational prompts, can have significant effects in the short run on interested outcomes, such as nutritional knowledge (Chapter 4) and healthy food choice (Chapter 5), but these effects can quickly dissolve after a relatively short period. The poor quality of the meals provided to children during lunch prevented the children from eating more fruit and vegetables, even though they were better aware of the issues of not eating enough FAV. Addressing the school meals' taste quality is crucial to the effectiveness of nutrition education. Additionally, providing access to healthy food in the school environment could be a good way to raise children's healthy food consumption, without a substitution effect between fruit provision at school and home fruit consumption.

Finally, Chapter 6 discusses the collective findings on the use of food systems approach for healthier outcomes, data gaps in food system research, and research transparency in practice. I also discuss the limitations of the thesis as a whole, such as lacking analyses on synergies and trade-offs within the food systems, limited external validity and scope of research methods. This thesis ends with a concise discussion on societal relevance of the studies.

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Mai Trang Nguyen
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Advanced Microeconomics, ECH 51806	WUR	2017	6
Experiments in Developing countries: Methods and Applications	University of Groningen Summer school	2017	2
Behavioral and Experimental Economics, ECH 51306	WUR	2017	6
Impact Assessment of Policies and Programs, DEC 32806	WUR	2017	6
B) General research related competences			
WASS Introduction	WASS	2017	1
Writing Research Proposal	WUR	2018	5
Scientific Publishing	Wageningen Graduate School	2017	0.3
Research Methodology - From Topic to Proposal	WASS	2017	4
Writing Grant Proposals	Wageningen in'to Languages	2019	2
Scientific Writing	Wageningen in'to Languages	2019	1.8
C) Career related competences/personal development			
"Overcoming fears of food safety: Testing innovative methods of influencing demand for healthy foods in Vietnam's schools"	33rd EFFoST Conference, Rotterdam	2019	1
"Testing innovative methods of influencing demand for healthy foods in Vietnam's schools"	1st WeValueFood Conference, Warsaw	2019	1
"Deconstructing the interactions between food environment and (un)healthy consumption: evidence along a rural-urban transect in Vietnam"	Global Food Security Conference, Online	2020	1
"Sweet or not: nudging towards healthier food choice for children using information and cognitive dissonance"	WASS PhD Day	2020	1
Career Assessment	Wageningen Graduate School	2020	0.3
Career Orientation	Wageningen Graduate School	2020	1.5
Total			**39.9**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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